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AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Departments of Plant Pathology and Entomology

FURTHER EXPERIMENTS IN THE DUSTING AND SPRAYING OF APPLES

By DONALD REDDICK and C. R. CROSBY

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Ithaca, New York, November 30, 1914.

DIRECTOR B. T. GALLOWAY,
College of Agriculture,
Ithaca, New York.

Dear Sir:

We beg to submit herewith a report of work done under the Herman Frasch Industrial Fellowship, with the recommendation that it be published as Experiment Station Bulletin 354.

The work was performed during the summer of 1914 in the orchards of Fred H. Glidden & Son, Holley, New York, E. W. Catchpole & Sons, North Rose, New York, and O. W. Friedah, Owego, New York. The writers are particularly indebted to these men for their hearty cooperation in placing their orchards at our disposal and in liberally aiding the investigations in every way possible.

Valuable assistance in various technical details of the experiments has been given by Dr. Robert Matheson and M. D. Leonard, of the Department of Entomology, Dr. V. B. Stewart and H. D. Hendricks, of the Department of Plant Pathology, and S. C. Bishop. The materials used were kindly furnished by the Union Sulfur Company, New York City, and the Corona Chemical Company, Milwaukee, Wisconsin; the dusting machines were furnished by the Kansas City Dust Sprayer Manufacturing Company.

Respectfully submitted,

DONALD REDDICK,
Professor of Plant Pathology.
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FURTHER EXPERIMENTS IN THE DUSTING AND SPRAYING OF APPLES

DONALD REDDICK AND C. R. CROSBY

(*Received for publication November 30, 1914*)

INTRODUCTORY

The appearance of a bulletin from this station by F. M. Blodgett[1] has renewed the interest of apple growers in the possibility of applying fungicides and insecticides in the dry state for the control of certain diseases and insects of the orchard, the most notable of which are scab disease, codling moth, leaf roller, and green fruit-worm. It appears from Blodgett's work that an exceedingly finely ground sulfur applied in the dry state is a fairly satisfactory substitute for lime-sulfur solution in the control of apple scab, and that powdered arsenate of lead, in the quantities used, is more effective in the control of the various insects that chew than is the same material applied in suspension in water according to the general practice. The data show that dusting is a much more rapid process than spraying, but that the cost per tree is greater for the dry method than for the wet.

The rigid requirements of the new apple packing law[2] have awakened an unusual interest in more efficient methods of disease and insect control, and the apparent vagaries of the fungus causing apple scab have again brought forcibly to the attention of apple growers the fact that "they may make all the applications of spray usually recommended for the orchard and still have scabby fruit." The statement is fully verified in the records to be found later in this bulletin. Many growers realize that the time of application is all-important in scab control, and many make an effort to cover their trees with spray at critical times. Lack of equipment or of sufficient help often prevents this, the latter item being the more important factor. The young orchards that are rapidly coming into bearing add to the difficulty, and altogether orchard spraying makes a big addition to the seasonal labor load.

The basis on which renewed trials of dry mixtures have been made is fully detailed by Blodgett in the bulletin already referred to, which includes also a résumé of previous work along the same line. The work reported in the present bulletin is a direct continuation of that done by Doctor Blodgett, and his advice and criticism were available in the planning of the work.

[1] Blodgett, F. M. Experiments in the dusting and spraying of apples. Cornell Univ. Agr. Exp. Sta. Bul. 340: 149-179. 1914.

[2] New York State Apple Grading Law. Chapter 418 of the Laws of 1914.

OBJECTS OF THE PRESENT INVESTIGATION

The important points for determination seemed to be as follows:

1. Is the dust method practicable in very large old trees, such as are frequently found in New York orchards? In order to answer this pertinent inquiry, a Baldwin orchard, approximately fifty years of age, was selected for one of the experiments. In picking the fruit, it was necessary to use ladders thirty feet long in some of the trees.

2. Can the results obtained in 1913 be duplicated or improved in another season?

3. Can a mixture be used that contains a smaller percentage of lead arsenate as the insecticidal agent? The work of 1912 indicated that a mixture containing 10 per cent of lead arsenate is effective, and as this is the expensive ingredient in the mixture it is desirable to reduce the quantity used as much as possible.

4. Can the quantity of fungicide applied per tree be reduced? This might have been done directly by applying smaller quantities, but, since the next point also was involved, it was accomplished by adding diluents.

5. Can the adhesive properties of the dry mixture be improved by the addition of an inert substance? Three substances, which from preliminary tests gave promise of success, were tried. These were (1) hydrated lime, a substance commonly used in many previous experiments; (2) finely ground gypsum, which is of about the same commercial value as hydrated lime but which will not react with the oxidation products of sulfur; (3) a cheap grade of wheat flour. The glutinous nature of the flour seemed, in previous tests and when used in considerable quantity, to improve the adhesiveness of the mixture.

6. Is the fine sulfur applied in suspension in water an efficient fungicide? The use of a paste sulfur mixture employed by Blodgett did not give particularly promising results, but it was thought worth while to make another trial of a home-prepared paste, using the finely divided sulfur employed in the dust mixtures.

The experiments of the season, therefore, hinged about these six considerations.

Comparisons were made with a plat of trees treated with the standard treatment, lime-sulfur solution and arsenate of lead, and with a plat of trees that received no summer treatment. Details as to quantities of material used, dates of application and conditions influencing the same, time required, comparative costs, results, and methods of recording data, are given in connection with the individual experiments.

For experimental purposes small trees are desirable, but if dusting is to prove of greatest value it must be effective in the very large old trees so frequently found in many of our orchards. Accordingly a Baldwin orchard

approximately fifty years of age was selected for one of the experiments. In the other two cases, the highly susceptible variety Ben Davis was used. The orchards are widely separated geographically, thus overcoming local variations and making any results obtained of general application.

EXPERIMENTS IN THE GLIDDEN ORCHARD AT HOLLEY

The experimental orchard at Holley consisted of a block of Baldwin trees twenty rows wide and twelve rows long, with other trees of the same size and age on three sides, as shown in Fig. 16. The black lines separate the

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	T
B	B	O	O	1	B	B	B	2	B	B	B	3	B	B	B	4	O	B	B	5	T
B	B	B	B	O	B	B	B	B	B	B	O	B	B	B	B	B	B	B	B	B	T
B	B	O	B	O	B	B	X	B	B	B	X	O	B	B	**B**^{3}	B	B	B	**B**^{3}	B	T
B	B	O	B	B	O	B	O	B	O	B	**B**^{3}	B	O	B	B	B	B	B	O	B	T
B	B	O	O	O	B	O	O	B	O	B	B	B	B	B	B	B	B	B	**B**^{2}	B	T
B	B	O	O	O	O	B	**B**^{3}	B	B	B	B	B	B	B	**B**^{2}	B	B	O	O	B	T
B	B	B	B	B	B	O	B	B	B	B	B	B	B	O	B	B	B	B	B	B	T
B	B	B	B	B	B	B	**B**^{2}	O	B	B	**B**^{2}	B	B	O	B	B	B	B	B	B	T
B	B	**B**^{3}	O	B	B	O	B	B	B	B	B	B	B	B	**B**^{1}	B	B	B	O	B	T
B	O	B	**B**^{1}	B	B	O	**B**^{1}	B	B	B	**B**^{1}	B	B	B	B	B	B	O	**B**^{1}	B	T
B	B	**B**^{2}	B	B	B	B	B	B	O	B	B	B	B	B	B	O	B	B	B	B	T
B	B	B	B	B	B	O	B	B	B	B	B	B	B	O	B	B	B	B	B	O	T

N
W — E
S

FIG. 16.— *Chart showing plan of experiments performed in the Glidden orchard, Holley, New York. The Baldwin trees (B) enclosed in the black lines represent the various plats, and the trees indicated by bold-faced type are the trees from which the apples were counted. The exponents refer to the order in which the data are presented in the table. B, Baldwin; T, Twenty Ounce; X, odd varieties; O, missing trees*

variously treated plats, and the letters set in bold-faced type indicate the trees from which counts were made. It was originally intended to count the yield from four trees, but this was found to be impracticable because of the amount of time and labor involved. The orchard seemed to be very uniform except for missing trees and a few odd varieties. In order to eliminate the personal equation, selection of count trees was made in June from a chart of the orchard. When a tree thus selected proved to be a poor and obviously unfair one or an odd variety, it was provided that the next tree beyond in the same row should be the count tree.

The block included an area of more than eight acres, with space for two hundred and forty trees set about forty feet apart each way. The land is nearly level, there being scarcely enough slope for drainage. This block is cultivated every other year. This year a sparse cover crop of clover was allowed to grow, but this was kept cropped close by sheep which were

allowed to run in the orchard. The trees are old, some of them are very large, and some need pruning badly. The orchard furnished an excellent opportunity for a test.

Methods and materials used

The solution used in the experiment in this orchard was applied with a power spraying outfit, carrying a pressure of 150 to 175 pounds, with two

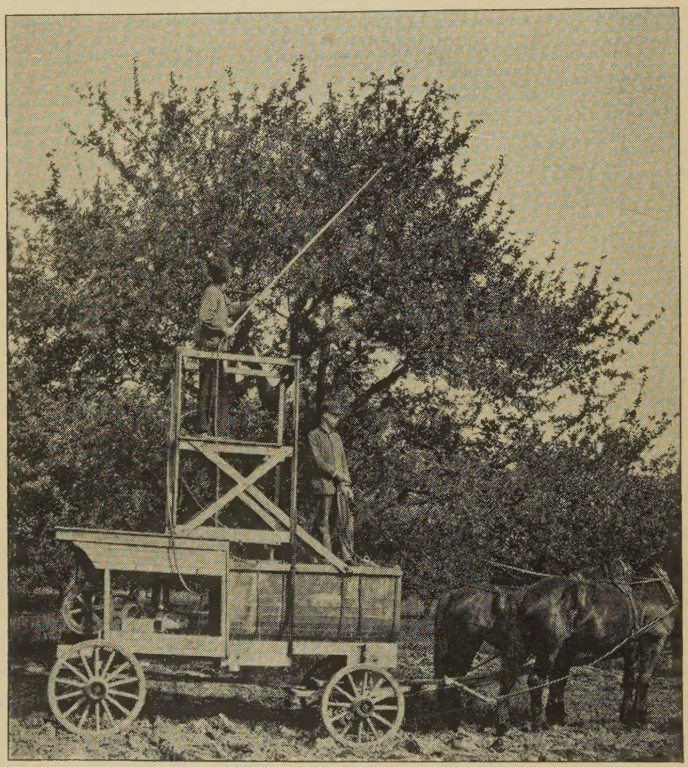


FIG. 17.—*Spraying outfit used in the Glidden orchard. Only one line of hose can be used profitably, due to the shape of the trees*

men and a team for its operation (Fig. 17). One line of hose was used and all the spraying was done from a tower. Considering the shape of the trees as shown in Figs. 18 and 19, this was a satisfactory method. It is the regular method employed by Mr. Glidden in forty acres or more of such trees.

The dust mixtures were applied with a large Ideal power outfit (Fig. 20), operated by a 2½-horsepower horizontal New Way gasoline engine. An engine of this horsepower furnished abundance of power, whereas a 1½-horsepower engine used by Blodgett did not seem to be large enough.

A dormant treatment of scale-strength lime-sulfur solution was applied to the entire block at a time when the first leaves were half grown. Three summer applications were made, the first at a time when the blossom buds still adhered in a cluster except in the tops of the trees. This was too early for pedicel protection from the scab fungus, but the various leaf-eating insects were abundant, and it was recalled that in 1913 the trees came into blossom in a very few days after the blossom buds reached the "cluster" stage. The second application was made when the blossoms had all fallen, and the third three weeks later. The first week in August one of the writers (R), in company with Mr. Glidden, examined the experimental block carefully and decided that there was no object in making a late application.

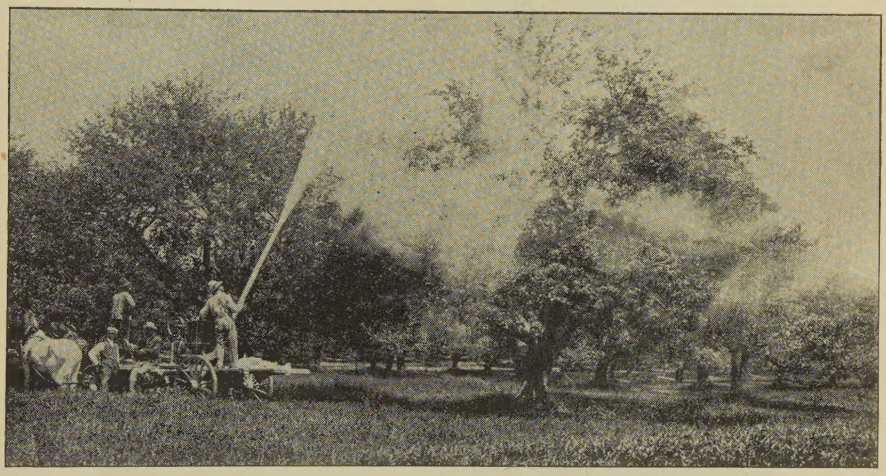


FIG. 18.—*Dusting in the Glidden orchard. The photograph shows the large size of the trees and the height to which the dust may be driven*

The fruit seemed to be unusually sound. How disastrously this resulted may be seen from a later table (Table 4).

In Table 1 are shown the dates, amounts of spray material used, and other data for the different applications. The cost figures are calculated on the basis of horse labor at 10 cents per hour, man labor at 20 cents per hour, lime-sulfur solution at 12 cents per gallon, dry arsenate of lead at 18 cents per pound, sulfur at $2.10 per hundred, ground gypsum at $8 per ton, and hydrated lime at $8 per ton. Obviously the figures are more or less arbitrary.[3] The cost of deterioration of the outfits is not taken into account, and the time lost in making adjustments of various sorts is not included in the record.

[3] Professor G. F. Warren, of the Department of Farm Management of this College, states that the cost of man labor here given is higher than the average and that of horse labor lower. Some of the prices of materials are based on large quantities and do not include freight charges. Since the figures are comparable in all cases, they are left in this form in order that they may be compared directly with the figures presented by Blodgett.

The relative cost per tree, also, is subject to considerable fluctuation. The dusting operations were not of sufficient duration to allow the operator to gauge accurately the quantity of material used per tree, as might be done in commercial work after a continuous run of half a day or even less. The time required per tree in spraying the experimental plat was greater than that required for treating trees of similar size and variety in the same orchard. On June 24 Mr. Glidden covered the same number of trees, of the same size, in one hour and fifty minutes. Since the same equipment was

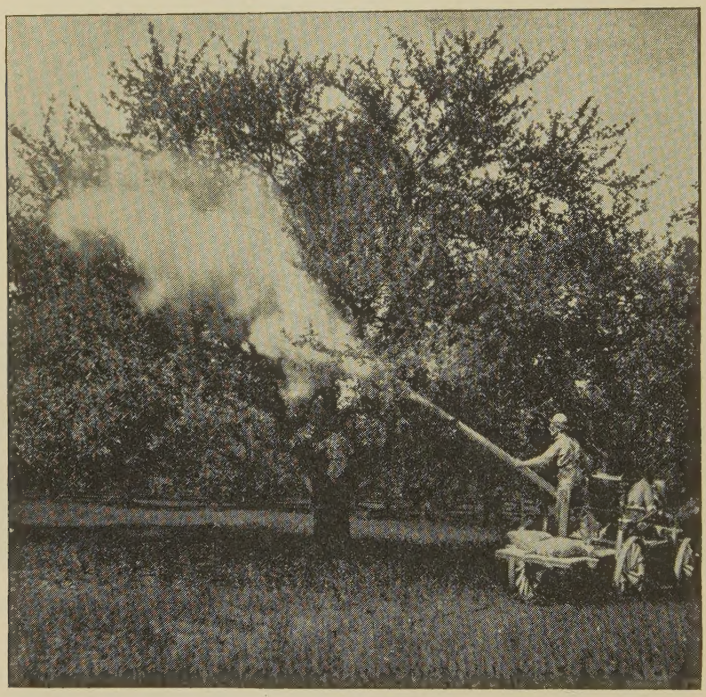


FIG. 19.—*Duster in operation in the Glidden orchard. The dust can be driven through trees with very dense foliage*

used, it is obvious that less material was used; and, other things being equal, the work must have been less effective, for no material was wasted, by dripping or otherwise, while the trees in the experimental plat were being treated. No allowance is made for time required in driving to and from the orchard, nor for filling the tank and mixing chemicals. For the entire orchard these operations may be estimated at thirty minutes for each tankful of mixture (200 gallons). Approximately this amount of time was required for the experiment, as the plats were somewhat less than halfway from the filling station to the most distant point in the orchard. It should be noted that, in dusting, enough material for a half day's work may be

TABLE 1. DATA ON TIME AND METHODS OF APPLICATION, GLIDDEN ORCHARD, HOLLEY, NEW YORK

Date of application	Plat	Number of trees	Material used, and strength	Quantity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Material	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
				(Lbs.)										
May 13	2	38	Sulfur 40, lead arsenate 10, hydrated lime 50	60	1	12	1	12	0	*36	$ .36	$ 1.70	$ 2.06	$.054
June 1	2	38		†140	1	20	1	20	0	40	.40	3.98	4.38	.115
June 18	2	38		160	‡1	32	1	32	0	46	.46	4.54	5.00	.131
Totals..	....	....	.....	360	4	04	4	04	2	02	$1.22	$10.22	$11.44	$.300
May 13	3	43		100	0	40	0	40	0	20	$ .20	$ 5.28	$ 5.48	$.127
June 1	3	43	Sulfur 80, lead arsenate 20	160	1	18	1	18	0	39	.39	8.45	8.84	.205
June 18	3	43		195	1	28	1	28	0	44	.44	10.30	10.74	.250
Totals..	....	....	.....	455	3	26	3	26	1	43	$1.03	$24.03	$25.06	$.582
May 13	5	41		80	0	42	...	42	0	21	$ .21	$ 2.27	$ 2.48	$.060
June 1	5	41	Sulfur 40, lead arsenate 10, gypsum 50	170	1	24	1	24	0	42	.42	4.83	5.25	.128
June 18	5	41		160	1	18	1	18	0	39	.39	4.54	4.93	.120
Totals	....	....	.....	410	3	24	3	24	1	42	$1.02	$11.64	$12.66	$.308
				(Gals.)										
May 14	4	43	Lime-sulfur solution (32°)	375	6	00	6	00	3	00	$1.80	$ 3.83	$ 5.63	$.131
June 1	4	43	2.5 gallons, lead arsenate	375	§6	00	6	00	3	00	1.80	3.83	5.63	.131
June 18 and 19	4	43	3 pounds, water to make 100 gallons	350	§6	00	6	00	3	00	1.80	3.57	5.37	.124
Totals..	....	....	.....	1,100	18	00	18	00	9	00	$5.40	$11.23	$16.63	$.386

*Several stops of short duration, too short to be recorded satisfactorily, were made.
†The mixture seemed to flow much more freely than on May 13.
‡A slower team was used, and the duster outlet was stopped down accordingly.
§Estimated from careful record taken on time required to treat thirty trees.

carried easily with the outfit. The cost per tree of spraying, therefore, should be materially increased over the figures given in the table.

All applications were made from both sides of the trees. The wind did not prove a hindrance except when it came in gusts, and no attempt was made to apply the dust to the trees while they were wet with dew. The first application of dust was made during gentle rain, and the application on plat 2 (sulfur-lead-lime mixture) was followed by a heavy shower of several minutes duration. The sprayed plat (plat 4) did not receive the first treatment until the day following the application of dust, as the gentle rain continued into the night. Ordinarily this would have vitiated the experiment, but it is doubtful whether it did so in this case. Infection of the scab fungus occurred at this date only from fallen leaves. A number of spores were ejected during this rain period, but as there had been rain on the two previous days it is probable that all the mature spores had been ejected at least twenty-four hours prior to the time of making any of the applications, and the low temperature at the time doubtless retarded maturation of other spores.

FIG. 20.—*Driving the dust to the top of a very large old Baldwin tree in the Glidden orchard*

It may be seen from the table that the cost of applying the dust mixtures is much less than for applying liquid, but that the dry materials are much more expensive. The cost of application of dust could doubtless be reduced somewhat below the figures given here. Later applications require a little more time than the first one, but in making the third application the duster was stopped down to half capacity because of a slowly moving team. The second application required more time because there was sufficient wind to make it uncertain that the cloud of dust directed at a certain part of the tree would actually reach it (Fig. 21). The machine, therefore, was moved at a rate which made it possible to redirect the flow toward that part of the tree if necessary.

It also appears from the table that the diluted dust mixtures were applied at approximately the same total cost per tree as was the solution. In reality the actual cost is lower, because of the fact that enough dry material may be carried along for a run of half a day, whereas in spraying much time is consumed in driving to and from the orchard and in filling the tank.

The relative quantities of the essential fungicidal and insecticidal ingredients applied per tree is of interest. According to Van Slyke, Bosworth, and Hedges (New York [Geneva] Agricultural Experiment Station, Bulletin

FIG. 21.—*Making an attempt to cover a branch missed the first time. The supply of material carried in bags should be noted also*

329, Table XI), a lime-sulfur concentrate testing 32° Beaumé contains 2.35 pounds of sulfur. Assuming that all the sulfur is liberated (which it is not), the sprayed trees in this orchard received at each application, on an average, 8.62 ounces of sulfur and 4.09 ounces of lead arsenate; trees in the plat dusted with 80-per-cent sulfur mixture received on an average 44.8 ounces of sulfur and 11.2 ounces of lead arsenate; those dusted with the mixture containing gypsum as a diluent received 21.3 ounces of sulfur and 5.33 ounces of lead arsenate; and those dusted with the mixture containing lime as a diluent received 20.16 ounces of sulfur and 5.04 ounces of lead arsenate.

TABLE 2. TRANSCRIPT OF RECORDS TAKEN AT THE ROCHESTER STATION OF THE WEATHER BUREAU OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

Date	Precipitation (inches)	Weather conditions
May 3	0	Partly cloudy
May 4	.02	Cloudy
May 5	.66	Cloudy
May 6	T*	Clear
May 7	.02	Partly cloudy
May 8	T	Cloudy
May 10	T	Cloudy
May 11	T	Cloudy
May 12	.68	Cloudy
May 13	.14	Cloudy
May 22	.05	Partly cloudy
May 23	0	Cloudy
May 24	0	Partly cloudy
May 25	.01	Partly cloudy
May 26	T	Partly cloudy
May 27	.16	Partly cloudy
May 29	T	Clear
May 30	.05	Clear
June 1	T	Clear
June 3	.03	Cloudy
June 4	.13	Cloudy
June 7	.28	Cloudy
June 8	0	Partly cloudy
June 13	0	Partly cloudy
June 15	T	Partly cloudy
June 16	.02	Clear
June 18	.25	Partly cloudy
June 19	.64	Cloudy
June 21	.08	Cloudy
June 22	.04	Cloudy
June 23	.03	Partly cloudy
June 24	T	Partly cloudy
June 26	T	Clear
June 27	.05	Cloudy
June 28	.08	Cloudy
June 29	.02	Cloudy
June 30	.06	Clear
July 1	.01	Cloudy
July 2	T	Cloudy
July 5	T	Clear
July 7	T	Cloudy
July 11	0	Partly cloudy
July 12	T	Partly cloudy
July 13	.01	Cloudy
July 14	T	Cloudy
July 16	.06	Partly cloudy
July 17	T	Cloudy
July 18	0	Partly cloudy
July 21	.08	Clear
July 23	.69	Cloudy
July 24	.02	Partly cloudy
July 25	.03	Clear
July 27	T	Cloudy

* Trace; an amount less than .01 inch, too small to be measured.

TABLE 2. (*continued*)

Date	Precipitation (inches)	Weather conditions
July 28	T	Partly cloudy
July 29	.01	Clear
July 31	0	Partly cloudy
August 1	0	Partly cloudy
August 2	.12	Partly cloudy
August 7	0	Partly cloudy
August 10	.59	Cloudy
August 11	.30	Cloudy
August 12	0	Partly cloudy
August 14	.21	Partly cloudy
August 16	.09	Partly cloudy
August 17	0	Partly cloudy
August 18	1.24	Cloudy
August 19	.02	Cloudy
August 20	.20	Cloudy
August 21	.46	Partly cloudy
August 23	.50	Cloudy
August 24	1.17	Cloudy
August 27	0	Partly cloudy
August 28	.12	Cloudy
August 29	.81	Cloudy
August 30	T	Partly cloudy
August 31	T	Partly cloudy

Diseases of the season

The only disease of any importance occurring in the orchard, amenable to the treatments given, was the scab disease (caused by *Venturia inaequalis*). Sooty blotch (caused by *Leptothyrium pomi*) was present to a limited extent in the untreated plat and on treated trees having very dense foliage.

Scab infection periods

It is a well-known fact that infections by the scab fungus are dependent on periods of rainfall, particularly when those periods are followed by foggy weather. Therefore a meteorological record of the season, properly interpreted, gives a general idea of the infection periods and their possible extent (Table 2). The season of 1914 was different from the preceding ones for a number of years, the first infection period (May 11, 12, and 13) coming before it was possible to make a first application to prevent pedicel infection. Considering that only the leaves of the blossom cluster had unfolded and that all infection was from the fallen leaves, the infection was unusually heavy. There ensued a dry period continuing through the blossoming period and extending through a sufficient time to allow making the calyx application on June 1. The dry period rendered useless the fungicide

applied the first time. At the date of the second application (June 1) the early infection showed abundantly on the under sides of the early leaves. These, of course, were largely leaves about the blossom cluster. No infections could be found on the pedicels of the young fruits, and none appeared subsequently. At the time when the second application was made, all the petals had dropped from the trees and the young apples were completely covered with a dense mat of fine hairs. This application afforded protection against infections occurring on June 3 and 4 and on June 7. These infections were much heavier than the first one, as spores (conidia)

FIG. 22.—*Dusting in the Glidden orchard. The picture shows well the method of applying the dust by long vertical sweeps of the outlet tube*

were abundant on the infected leaves and spores (ascospores) were also shot from the fallen leaves in great abundance.

The third application was made on June 18. This application was most opportune, since it forestalled the largest infection of early summer.

The month of July was unusually dry (Table 2), and no further infection occurred in this orchard. As the amount of scab on the fruit seemed to be exceedingly slight and as there was no evidence of codling moth, the fourth application was omitted. August, however, proved to be a rainy month, and an unusually heavy late infection of scab occurred throughout the entire orchard.

Insects of the season

On May 12-13 Dr. R. Matheson visited the orchard and found that the bud moth was fairly abundant, 25 to 30 per cent of the buds on the branches near the ground being infested. The cigar case-bearer was also abundant, all the lower leaves being somewhat injured. On June 1 the orchard was again visited, by one of the writers (C). The apple leaf-roller was fairly abundant and the caterpillars were beginning to eat the stamens and the calyx lobes of the recently set apples. Only one fruit was seen that showed the characteristic feeding of the leaf roller at the side. A few green-fruit worm caterpillars were observed at this time. Neither the first nor the second brood of codling moth was abundant, as is shown by the count of apples from the untreated plat.

The injury designated in Table 4 as "pinholes" should probably be attributed to several causes. These pinholes are slight blemishes, usually less than $\frac{1}{8}$ inch in diameter, with a small hole at the center often partly filled with a whitish substance. The flesh of the fruit beneath the blemish has dried out and turned brownish to a depth of about $\frac{1}{8}$ inch. Some of these spots may have been caused by codling-moth caterpillars that died after eating through the skin of the fruit, but the greater number were produced in some other way. It should be noted that in the Glidden orchard, where the apples are Baldwins, about 18 per cent of the fruits in the untreated plat were affected with pinholes, while at North Rose and at Owego the Ben Davis apples were not injured in this way.

Results of experiments

Apples that failed to set were caught in cheesecloth hammocks suspended under the count trees. None of these apples showed pedicel infection. An examination was made of the orchard on June 25. The infection of June 19 was not yet apparent. In order to confirm an impression that the infection from fallen leaves is greatest on the lower branches, as would be expected from the purely physical aspects of the case, a number of branches in the untreated plat were selected at random from the lower limbs and from limbs high in the tree. One thousand leaves were stripped from each lot of branches and the number of infected ones was determined. Of the lower leaves 39 per cent were infected, and of the upper leaves 30 per cent. No account is taken of the number of infections per leaf, and it should also be borne in mind that some of the infections were secondary. To be of most value, the count should have been made ten days earlier.

On July 10 all the drops from one of the count trees, and equal quantities from the other three, in each plat, were examined and graded into four classes: sound; scabby; attacked by leaf roller or green fruit-worm; attacked

by codling moth. The accompanying table (Table 3) shows the percentage of fruit for each class.

The table shows the expected reduction in amount of apple scab in the treated plats. It also indicates that the poisons were not effective against certain of the leaf-eating insects. It is chiefly valuable, however, in showing the practical freedom of the entire orchard from codling moth. The apples were picked and graded October 13 to 21. On October 11 a heavy wind caused a number of apples to fall. As it was thought these apples might show excessive injuries, they were graded separately. No such condition was found to exist, however, and these windfalls were counted in with the picked apples.

TABLE 3. CLASSIFICATION OF DROP APPLES ON JULY 10, 1914, GLIDDEN ORCHARD

Treatment	Total number of apples	Sound		Apple scab		Leaf roller and green fruit-worm		Codling moth	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	488	337	69.06	95	19.47	69	14.14	1	.02
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons	661	545	82.45	10	1.51	106	16.04	0	0
Sulfur 80, lead arsenate 20	387	307	79.33	18	4.65	62	16.02	0	0
Sulfur 40, lead arsenate 10, gypsum 50	2,071	1,828	88.27	30	1.45	211	10.19	2	.10
Sulfur 40, lead arsenate 10, hydrated lime 50	507	403	79.49	36	7.10	78	15.38	0	0

After two trees had been graded (Fig. 23), it became apparent that it would be physically impossible to count the apples from twenty trees. It was therefore decided to grade the fruit from only three trees in each plat, instead of from four as originally planned. The elimination of one count tree from each plat was left largely to chance. It depended chiefly on whether the tree had been picked or not, and in part on nearness to the last tree counted.

In making the tabulation the apples were first divided into sound and unsound. The unsound apples were further classified, each individual apple falling under one to six headings, depending on whether or not it was affected with scab from early infection or with scab from late infection; whether leaf roller and green fruit-worm had attacked it; whether or not codling moth and bud moth had attacked it in August; and whether the apples showed lesions which for want of a better name were designated as " pinholes."

No difficulty was experienced in separating the early-scab-infected apples from those affected late in the season. This separation is important, since the treatments given could not be expected to control the late infection. It should be noted, however, that late infection is very much greater on the untreated plat than on any of the others. This is attributable directly to better control of early scab. It was noted that in the treated plats apples bearing early scab spots were almost sure to show late infection also. The record of late infection is of considerable importance in the light of the new packing law. Technically a very large percentage (15 per cent or more) of these apples could not be sold in closed packages unless labeled, in thirty-six-point Gothic letters, either "Fungused" or "Scabby."[4] Some of the scab spots were very small, and often there was only a single spot on an apple. There is some question as to whether such spots should exclude an apple from standard A or B grade, particularly in view of the fact that under modern cold storage no further damage should result. The words "practically free" as written in the law would certainly allow some of the apples graded as scabby to pass, but just where the line should be drawn seems to be an open question. As the apples from this orchard were sold "tree run," it was not necessary for the writers to settle this point.

Fig. 23.—*The number of apples per tree made it impracticable to classify the fruit from more than three trees in each plat*

A suitable method of recording the number of infections per apple is highly desirable, but there seems to be no practicable way of doing this when handling such large quantities of fruit. The result is that in the tabulation (Table 4) an apple wholly worthless from scab counts just the same as one bearing a small spot scarcely visible except when the light strikes from the proper angle.

[4] New York State Apple Grading Law. Chapter 418 of the Laws of 1914.

The relative value of the various materials used may be seen from Table 4. Percentages have been determined, and the mean of these percentages with the probable error[5] of the mean. This seems to be the method most frequently employed by biologists in statistical work of this kind. The method permits one to take into consideration the numerous factors that can be neither controlled nor calculated in such work. Some of the more important of these factors may be enumerated as follows, in their apparent order of importance: individuality of trees, particularly in their relative susceptibility; density of foliage and general shape of trees, in their relation more especially to fungous infection;

FIG. 24.—*Classifying the apples as they came from the trees. Each type of injury was recorded by means of a mechanical device*

failure to make uniform applications during the course of the experiment or during the preceding year. The error due to these factors can be considered as a casual one, and as such can be determined by calculating the probable error. This is a measure of the reliability of the experimental results, and means that the odds are equal that the true result lies somewhere within the data actually obtained ± the probable error.

Some persons dealing with statistics do not look on this method with favor, and in order to see what variations might occur the averages obtained by using totals have been determined. The writers are not in accord as to the more suitable method, and as it became increasingly apparent that the matter could not be settled a priori both sets of figures are presented here.

[5]The probable error as worked out is equal to $\pm 0.67 \sqrt{\frac{\sum d^2}{n(n-1)}}$

TABLE 4. CLASSIFICATION OF BALDWIN APPLES FROM THE GLIDDEN ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab				Leaf roller and green fruit-worm		Pinholes		Bud moth		Codling moth	
						Early		Late									
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	2,977	313	10.51	2,664	89.49	942	31.64	2,305	77.43	625	20.99	541	18.17	64	2.150	57	1.9147
	3,011	165	5.48	2,846	94.52	967	32.12	2,423	80.47	781	25.94	610	20.26	69	2.292	27	0.8967
	8,193	278	3.39	7,915	96.61	3,256	39.74	7,467	91.14	1,854	22.63	1,425	17.39	245	2.990	53	0.6467
Total	14,181	756	.....	13,425	.....	5,165	.....	12,195	.....	3,260	.....	2,576	.....	378	.....	137	.....
Mean	.....	.....	**6.46**	.....	**93.54**	.....	**34.50**	.....	**83.01**	.....	**23.18**	.....	**18.61**	.....	**2.477**	.....	**1.1528**
Probable error	.....	.....	±1.42	.....	±1.42	.....	±1.75	.....	±2.79	.....	±.98	.....	±.58	.....	±.076	.....	±.26
Average	.....	.....	5.33	.....	94.67	.....	36.42	.....	85.99	.....	22.99	.....	18.16	.....	2.665	.....	0 9661
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons	6,260	4,438	70.89	1,822	29.11	380	6.07	696	11.12	619	9.89	432	6.90	226	3.610	14	0.2236
	5,509	2,964	53.80	2,545	46.20	507	9.20	1,099	19.95	1,052	19.10	533	9.68	214	3.885	17	0.3086
	4,122	2,684	65.11	1,438	34.89	234	5.68	663	16.08	501	12.15	397	9.63	116	2.814	0	.....
Total	15,891	10,086	.....	5,805	.....	1,121	.....	2,458	.....	2,172	.....	1,362	.....	556	.....	31	.....
Mean	.....	.....	**63.27**	.....	**36.73**	.....	**6.98**	.....	**15.72**	.....	**13.71**	.....	**8.74**	.....	**3.436**	.....	**0.1774**
Probable error	.....	.....	±3.36	.....	±3.36	.....	±.74	.....	±1.71	.....	±1.86	.....	±.61	.....	±.099	.....	±.0616
Average	.....	.....	63.47	.....	36.53	.....	7.05	.....	15.47	.....	13.67	.....	8.57	.....	3.499	.....	0.1951
Sulfur 80, lead arsenate 20	3,630	2,416	66.56	1,214	33.44	139	3.83	579	15.95	343	9.45	263	7.25	125	3.444	22	0.6061
	3,257	2,514	77.19	743	22.81	131	4.02	331	10.16	212	6.51	149	4.58	54	1.657	7	0.2149
	3,186	2,175	68.27	1,011	31 73	116	3.64	518	16.26	302	9.48	234	7.34	51	1.600	2	0.0614
Total	10,073	7,105	.....	2,968	.....	386	.....	1,428	.....	857	.....	646	.....	230	.....	31	.....
Mean	.....	.....	**70.67**	.....	**29.33**	.....	**3.83**	.....	**14.12**	.....	**8.48**	.....	**6.39**	.....	**2.234**	.....	**0.2941**
Probable error	.....	.....	±2.20	.....	±2.20	.....	±.07	.....	±1.33	.....	±.66	.....	±.61	.....	±.41	.....	±.109
Average	.....	.....	70.54	.....	29.46	.....	3.83	.....	14.18	.....	8.51	.....	6.41	.....	2.283	.....	0.3078
Sulfur 40, lead arsenate 10, gypsum 50	4,761	3,449	72.44	1,312	27.56	79	1.66	462	9.70	321	6.74	411	8.63	164	3.445	0	.....
	5,964	3,769	63.20	2,195	36.80	221	3.71	1,074	18.01	595	9.98	572	9.59	186	3.119	0	.....
	6,665	4,220	63.32	2,445	36.68	421	6.32	1,143	17.15	479	7.19	742	11.13	169	2.536	2	0.0300
Total	17,390	11,438	.....	5,952	.....	721	.....	2,679	.....	1,395	.....	1,725	.....	519	.....	2	.....
Mean	.....	.....	**66.32**	.....	**33.68**	.....	**3.90**	.....	**14.95**	.....	**7.97**	.....	**9.78**	.....	**3.033**	.....	**0.0115**
Probable error	.....	.....	±2.05	.....	±2.05	.....	±.90	.....	±1.76	.....	±.68	.....	±.49	.....	±.178	.....	±.0006
Average	.....	.....	65.77	.....	34.23	.....	4.15	.....	15.41	.....	8.02	.....	9.92	.....	2.984	.....	0.0115
Sulfur 40, lead arsenate 10, hydrated lime 50	5,865	2,382	40.61	3,483	59.39	484	8.25	2,412	41.13	881	15.02	738	12.58	26	0.443	9	0.1535
	3,571	1,982	55.50	1,589	44.50	214	5.99	941	26.35	404	11.31	378	10.59	86	2.408	4	0.1120
	4,554	2,157	47.36	2,397	52.64	564	12.38	1,850	40.62	302	6.63	400	8.78	137	3.008	11	0.2415
Total	13,990	6,521	.....	7,469	.....	1,262	.....	5,203	.....	1,587	.....	1,516	.....	249	.....	24	.....
Mean	.....	.....	**47.82**	.....	**52.18**	.....	**8.87**	.....	**36.03**	.....	**10.99**	.....	**10.65**	.....	**1.953**	.....	**0.1620**
Probable error	.....	.....	±2.88	.....	±2.88	.....	±1.25	.....	±3.24	.....	±1.62	.....	±.74	.....	±.511	.....	±.026
Average	.....	.....	46.61	.....	53.39	.....	9.02	.....	37.19	.....	11.34	.....	10.84	.....	1.780	.....	0.1716

The greatest care has been taken to have the figures accurate. The records in the field were made on counting machines (Fig. 24). In making transcriptions all figures have been checked twice. All computations have been made by means of mechanical devices by one of the writers (R), and checked independently by M. D. Leonard and again in the editorial office at the College of Agriculture.

Scab control.— It is seen from the table that all the materials used gave very satisfactory control of early scab. Particular attention should be given to the variation of the individual trees in any one plat. In general, trees bearing a relatively small number of apples had less scab; trees on which the fruit was very highly colored seemed to have less scab, although not enough of this kind of trees were encountered to permit a generalization; apples from the north side of trees invariably had more scab. The greater abundance of scab on the north side of trees can be accounted for only by the fact that the very dense foliage allowed moisture to persist there longer after each shower, and thus allowed more infections to occur.

Blodgett[6] found that the use of lime as a diluent for sulfur in the control of hop mildew reduced the fungicidal value of the sulfur. It does not necessarily follow, however, that the same result would be obtained in the case of an organism the method of infection of which is different. It seemed possible, therefore, that the hydrated lime, which hardened on the foliage and adhered well, might not prove harmful in the control of apple scab. The heavy shower coming on this plat shortly after the first application vitiates the figures to a certain extent. This point will be discussed more fully in the general summary.

Insect control.—Codling moth injury was so slight, even in the untreated plat, that the figures given in the table have little significance. The data in regard to the control of August injury by bud-moth caterpillars are also of little value, because in order to be effective the application of the poison should have been made in the last week of July or early in August, soon after the hatching of the eggs.

It may be seen from the table that the pinhole injury, whatever its cause, was reduced from 18.16 per cent in the untreated plat to less than 11 per cent by the various treatments given. In considering the control of leaf roller, it should be remembered that in these experiments the applications were made much too late to be fully effective.

Sound and unsound fruit.— From the figures in Table 4 it may be seen that in total percentage of sound and unsound fruit there is no dependable difference between the various mixtures used except in the case when lime was used as a diluent. Whether this is due to the unfavorable

[6] Blodgett, F. M. Hop mildew. Cornell Univ. Agr. Exp. Sta. Bul. 328 : 298. 1913.

action of lime in the mixture, or to the heavy shower that came shortly after the first application was made, is uncertain. The other two dust mixtures seem to have been slightly superior to the lime-sulfur solution with lead arsenate, but the probable error is so large as to make this uncertain.

So far as this orchard is concerned, the first question to be determined (page 54) can be answered in the affirmative. The dust method is practicable in large trees. Based on the figures just presented, the second question can also be answered affirmatively. The result of 1913 has been somewhat improved upon, in that a higher percentage of sound apples has been secured with a similarly low percentage of sound fruit on the untreated plat.

Experiments in the Catchpole Orchard at North Rose

The trees used for experimental purposes this year in the Catchpole orchard are located only a short distance from those used last year by Doctor Blodgett. They are of the variety Ben Davis, a variety particularly susceptible to scab. The trees are twenty years of age, are set 33 by 33 feet, and are very uniform in size and shape. The system of pruning employed is that of very light annual pruning. The trees are very dense and the lower branches reach to the ground (Fig. 25). Repeated and thorough spraying is practiced annually. The soil is a sandy loam and the ground is practically level. The orchard is fertilized, cover-cropped, and thoroughly cultivated between the rows each year. The system of pruning prevents cultivation directly under the trees. Fallen leaves of the previous year persist under the trees, and when scabby they form a hotbed of infection. This was the case in 1914.

It will be seen from the plan of the experiment (Fig. 26) that the plats are bordered on three sides by trees of the same size and age. The count trees here (indicated by bold-faced type), as elsewhere, were predetermined from a chart of the orchard.

Methods and materials used

The solution used on the sprayed plat was applied with a large power sprayer, with a pressure of 150 pounds or more and with three men and a team for its operation (Fig. 25). The dusting machine was like the one used in the Glidden orchard. It was driven by a $2\frac{1}{2}$-horsepower horizontal New Way engine, which furnished ample power and was a great improvement over the equipment of the previous year.

Particular mention should be made of the thorough manner in which the trees were sprayed. It will be seen from Table 5 that more than

five gallons of spray was applied per tree at each application. This was accomplished by driving completely around each tree, thus covering all parts thoroughly.

All applications of the dust mixtures were made from both sides of the trees. The first application was made on a calm day and the work was done very quickly. At the time of the second application there was

FIG. 25.—*Spraying in the Catchpole orchard. The photograph shows well the size and shape of the trees in this orchard*

a high wind, which came in sharp gusts and made impossible a thorough application of dust. There was also more wind at the time of the third and fourth applications than is desirable for dusting. A dormant treatment of scalecide was applied to the entire block. Four summer applications were made. At the time of the first application (May 15) the clusters of buds were beginning to separate and show pink, but many

were not far enough along to permit driving the fungicide to the pedicels of the innermost blossoms. The second application was made on May 30, at a time when all the petals had fallen. The third application was made on June 19 and was gauged rather for codling moth than for scab. The fourth application was made on August 7, largely to forestall a possible late infection of scab. Each time the treatment of the various plats was made in the forenoon of the same day.

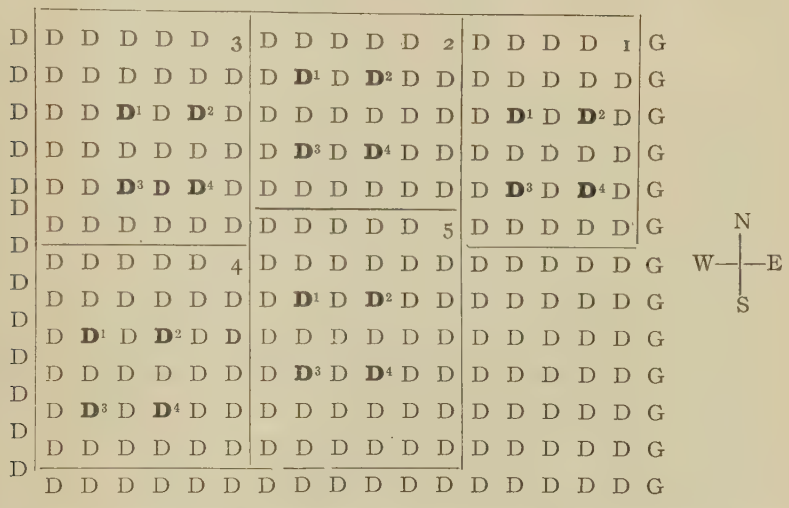


FIG. 26.— *Chart showing plan of experiment performed in the Catchpole orchard, North Rose, New York. The Ben Davis trees (D) enclosed in the black lines represent the various plats, and the trees indicated by bold-faced type are the trees from which the apples were counted. The exponents refer to the order in which the data are presented in the tables. D, Ben Davis; G, Greening*

By mistake the trees in plat 1 (dusted with sulfur, lead arsenate, and hydrated lime) received an application of bordeaux mixture, from one side only, on May 14, the day previous to the first application of the dust mixture. As this was applied too late to prevent the primary infection, and as no other infections occurred until after the blossoms were off, presumably it did not interfere in any way with the experiment.

Details of the dates of application, materials used, time required, cost data, and so forth, are shown in Table 5. The cost figures are calculated on the same basis as in the Glidden orchard. The cost of deterioration of outfits, interest on investment, and so forth, are not considered, and the time lost in making adjustments is not included in the records.

TABLE 5. DATA ON TIME AND METHODS OF APPLICATION, CATCHPOLE ORCHARD, NORTH ROSE, NEW YORK

Date of application	Plat	Number of trees	Material used, and strength	Quantity used	Time required: Horse Hrs.	Horse Min.	Man Hrs.	Man Min.	Machine Hrs.	Machine Min.	Cost: Labor	Material	Total cost	‡Cost per tree
				(Lbs.)										
May 15*	1	30	Sulfur 40, lead arsenate 10, hydrated lime 50	70	0	26	0	26	0	13	$.13	$1.99	$2.12	$.071
May 30	1	30		80	0	†50	0	50	0	25	.25	2.27	2.52	.084
June 19	1	30		95	0	42	0	42	0	21	.21	2.70	2.91	.097
Totals..	....	....	.....	245	1	58	1	58	0	59	$.59	$6.96	$7.55	$.252
May 15	3	36		70	0	30	0	30	0	15	$.15	$ 3.70	$ 3.85	$.107
May 30	3	36	Sulfur 80, lead arsenate 20	90	0	56	0	56	0	28	.28	4.75	5.03	.140
June 19	3	36		130	0	48	0	48	0	24	.24	6.86	7.10	.197
Totals..	....	....	.....	290	2	14	2	14	1	07	$.67	$15.31	$15.98	$.444
May 15	4	36		70	0	27	0	27	0	13	$.13	$1.99	$2.12	$.059
May 30	4	36	Sulfur 40, lead arsenate 10, gypsum 50	100	0	56	0	56	0	28	.28	2.84	3.12	.087
June 19	4	36		90	0	40	0	40	0	20	.20	2.56	2.76	.077
Totals	....	....	.....	260	2	03	2	03	1	01	$.61	$7.39	$8.00	$.223
				(Gals.)										
May 15	5	42	Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons	§225	1	40	2	30	0	50	$ .67	$1.69	$2.36	$.056
May 30	5	42		225	1	40	2	30	0	50	.67	1.69	2.36	.056
June 19	5	42		225	1	40	2	30	0	50	.67	1.69	2.36	.056
Totals	....	....	.....	675	5	00	7	30	2	30	$2.01	$5.07	$7.08	$.168

* By mistake trees in this plat were treated on May 14, from one side only, with bordeaux mixture 3-3-50 and powdered arsenate of lead (30%) 1¼-50.
† It was necessary to stop at each tree because of the high wind.
‡ No record was made of time or material used in late application. Approximately one third more may be added to this figure.
§ The quantity applied per tree is greater than was used by the owner on adjacent trees of the same age.

Owing to the very efficient methods of spraying employed in this orchard (Figs. 25 and 27), the time required for covering a tree thoroughly is not so long as in most orchards. The result is that the cost per tree for spraying appears to be less than for dusting. When the time required for driving to and from the orchard and for filling the tank is counted in, it is probable that the total cost per tree for spraying would about equal the total cost per tree for dusting with the diluted mixture. No accurate data are available on the time element involved, and the three records made under the conditions of the experiment are of little value in determining the average. Through an oversight records were not kept at the time of the fourth application. To determine the total cost per tree for the season, approximately one third more should be added to the cost indicated in the table.

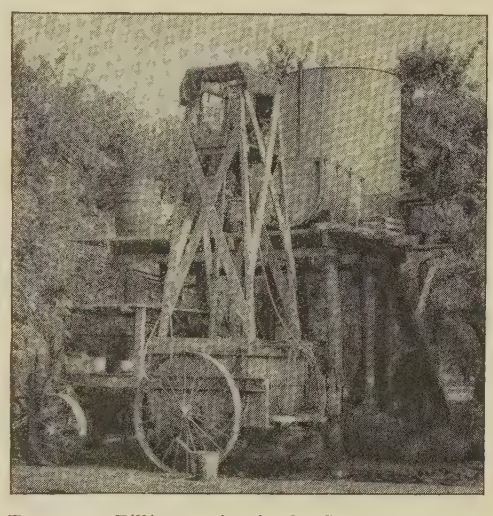


FIG. 27.—*Filling station in the Catchpole orchard. The convenient arrangement of this filling station makes it possible to load and get away in seven minutes. It helps to reduce the cost of spraying, but, what is more important, it helps to keep the sprayer working at maximum capacity*

The average relative quantities of essential fungicidal and insecticidal ingredients applied per tree each time are as follows: sprayed plat, sulfur 5.42 ounces, lead arsenate 2.57 ounces; plat dusted with 80-per-cent sulfur mixture, sulfur 34.30 ounces, lead arsenate 8.58 ounces; plat dusted with mixture containing gypsum as a diluent, sulfur 15.36 ounces, lead arsenate 3.84 ounces; plat dusted with mixture containing lime as a diluent, sulfur 17.41 ounces, lead arsenate 4.35 ounces.

Diseases of the season

The only disease occurring in this orchard amenable to the treatments given was scab. Here, as in the Glidden orchard, the first infection occurred May 11, 12, and 13. The fallen leaves of the previous year formed a dense mat under the trees and bore abundant fruiting bodies of the scab fungus, some of which likewise were mature earlier than usual.

Scab infection periods

At the time of the second application in this orchard, May 30, the infections of May 11, 12, and 13 were showing abundantly on the under

sides of the leaves about the blossom cluster. There was rain during the night of May 28 and a light shower at six o'clock on the morning of May 30. As these rains were followed by high wind and clearing weather, the amount of infection occurring was not very great. It was sufficient, however, to furnish an abundant supply of fresh spores for the most important infection period of the season. By reference to the Rochester weather record (Table 2) it may be seen that infection weather occurred on June 3 and 4, and on June 7. The rain recorded for Rochester on June 18 did not occur at North Rose. The third application was made in the forenoon of June 19, and at three o'clock in the afternoon of the same day rain set in which developed into a drenching torrent. The solution applied had had time to partially set on the trees, but it is quite probable that the dust mixtures were washed off as there had been no opportunity for dew or any other agency to assist in bringing about better adherence.

It seems likely that much infection took place during the night of June 19, and that much more occurred on June 21, 22, 23, and 24 — a most excellent period for infection, with just enough rain to keep the foliage wet and enough cloudiness to prevent too rapid drying-out of the drops. There was little additional infection weather during the summer, until the mid-August period. At that time abundant late infection occurred.

Insects of the season

The Catchpole orchard was singularly free from injurious insects subject to control by the treatments. Only a small number of leaf-roller and green-fruit-worm caterpillars were present. Neither codling moth nor bud moth was abundant. The pinhole injury, so prevalent in the Glidden orchard, was not present here.

Results of experiments

As in the Glidden orchard, pedicel infection by the scab fungus did not occur. This may be attributed directly to the dry period during the latter half of May. An examination of the orchard was made on June 27. It was evident that the infections occurring during the night previous to the second application (the night of May 29) were of considerable extent. These spots showed both on the older leaves from leaf buds and on the young fruits.

On July 7 additional infections from June 19 and June 21, 22, 23, and 24 were coming into evidence. The drop apples were picked up on this date from under the count trees, and were examined and classified. The classification is shown in Table 6:

TABLE 6. CLASSIFICATION OF DROP APPLES PICKED UP ON JULY 7, 1914, CATCHPOLE ORCHARD

Treatment	Total number of apples	Sound		Apple scab		Leaf roller and green fruit-worm	
		Number	Percentage	Number	Percentage	Number	Percentage
Untreated	230	58	25.22	162	70.43	12	5.22
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons	414	321	77.54	87	21.01	6	1.45
Sulfur 80, lead arsenate 20	324	190	58.64	134	41.36	0	0
Sulfur 40, lead arsenate 10, gypsum 50	329	96	29.18	228	69.30	12	3.65
Sulfur 40, lead arsenate 10, hydrated lime 50	236	140	59.32	84	35.59	12	5.08

A decided reduction in scab is indicated for the sprayed plat, and the averages for the various plats will be found to agree fairly closely with later classifications from the same trees.

On August 7 the trees in the entire orchard were thinned. The men who did this work were instructed to remove unsound fruit whenever there was a preference. The classification (Table 7) of these apples, therefore, should be held in mind in interpreting the table given later for picked apples.

The relative value of the various materials used may be seen from Table 8. The computations have been made with the same care as for the Glidden orchard. In this orchard, where the yield per tree was four to six barrels, it was possible to classify the fruit from all four count trees. This increases the probability that the figures given represent a true mean for the various plats. If one thousand apples could have been taken at random from each of ten trees, the actual labor would not have been increased and a more reliable mean could have been secured. Under the system of picking employed, however, this could not be done because of the difficulty of securing random samples, and this in turn was due to the fact that lower branches bore more scabby fruit than did those in the tops of the trees and apples on the north side of trees were more scabby than those on the south side.

Scab control.— The table shows a very high percentage of early summer infection on untreated trees, which can be attributed to the large amount of infection material under the trees, to the fact that a severe primary infection occurred before a protective coating could be applied, and to the prolonged period of infection weather — June 21, 22, 23, and 24. The late infections were very abundant also. Almost invariably apples showing early infection also showed the late attack, and in addition

TABLE 7. CLASSIFICATION OF BEN DAVIS APPLES REMOVED FROM THE TREES ON AUGUST 7, 1914, CATCHPOLE ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Leaf roller and green fruit-worm		Codling moth		Curculio	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	1,530	36	2.35	1,494	97.65	1,390	90.85	95	6.209	7	0.4575	0	.....
	1,377	37	2.69	1,340	97.31	1,150	83.51	100	7.262	5	0.3631	0	.....
	1,497	43	2.87	1,454	97.13	1,330	88.84	160	10.688	4	0.2672	0	.....
	1,305	192	14.71	1,113	85.29	990	75.86	130	9.962	3	0.2299	0	.....
Total	5,709	308	.....	5,401	.....	4,860	.....	485	.....	19	.....	.....	.....
Mean	.....	.....	**5.66**	.....	**94.34**	.....	**84.76**	.....	**8.530**	.....	**0.3294**	.....	.....
Probable error	.....	.....	±2.02	.....	±2.02	.....	±2.24	.....	±.71	.....	±.034	.....	.....
Average	.....	.....	5.40	.....	94.60	.....	85.13	.....	8.495	.....	0.3328	.....	.....
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons	1,412	771	54.60	641	45.40	560	39.66	75	5.312	0	.....	23	1.629
	1,202	667	55.49	535	44.51	470	39.10	77	6.406	0	.....	16	1.331
	586	470	80.20	116	19.80	87	14.85	20	3.413	0	.....	6	1.024
	1,530	750	49.02	780	50.98	665	43.46	174	11.373	0	.....	37	2.418
Total	4,730	2,658	.....	2,072	.....	1,782	.....	346	.....	.....	.....	82	.....
Mean	.....	.....	**59.83**	.....	**40.17**	.....	**34.27**	.....	**6.626**	.....	.....	.....	**1.601**
Probable error	.....	.....	±4.65	.....	±4.65	.....	±4.38	.....	±1.14	.....	.....	.....	±.22
Average	.....	.....	56.19	.....	43.81	.....	37.67	.....	7.315	.....	.....	.....	1.734
Sulfur 80, lead arsenate 20	1,259	393	31.22	866	68.78	805	63.94	82	6.513	0	.....	0	.....
	1,023	407	39.78	616	60.22	578	56.50	55	5.376	6	0.5865	0	.....
	1,513	389	25.71	1,124	74.29	985	65.10	110	7.270	4	0.2644	0	.....
	1,060	335	31.60	725	68.40	565	53.30	58	5.472	6	0.5660	0	.....
Total	4,855	1,524	.....	3,331	.....	2,933	.....	305	.....	16	.....	.....	.....
Mean	.....	.....	**32.08**	.....	**67.92**	.....	**59.71**	.....	**6.158**	.....	**0.3542**	.....	.....
Probable error	.....	.....	±1.94	.....	±1.94	.....	±1.92	.....	±.302	.....	±.093	.....	.....
Average	.....	.....	31.39	.....	68.61	.....	60.41	.....	6.282	.....	0.3296	.....	.....
Sulfur 40, lead arsenate 10, gypsum 50	2,061	173	8.39	1,888	91.61	1,780	86.37	109	5.288	0	.....	6	0.2911
	1,362	66	4.85	1,296	95.15	1,260	92.51	86	6.314	0	.....	5	0.3671
	2,049	100	4.88	1,949	95.12	1,835	89.56	234	11.420	0	.....	0	.....
	2,302	176	7.65	2,126	92.35	1,990	86.45	128	5.560	0	.....	47	2.0417
Total	7,774	515	.....	7,259	.....	6,865	.....	557	.....	.....	.....	58	.....
Mean	.....	.....	**6.44**	.....	**93.56**	.....	**88.72**	.....	**7.145**	.....	.....	.....	**0.6750**
Probable error	.....	.....	±.62	.....	±.62	.....	±.98	.....	±.965	.....	.....	.....	±.310
Average	.....	.....	6.62	.....	93.38	.....	88.31	.....	7.165	.....	.....	.....	0.7461
Sulfur 40, lead arsenate 10, hydrated lime 50	547	100	18.28	447	81.72	325	59.41	102	18.647	4	0.7313	6	1.0969
	834	259	31.06	575	68.94	485	58.15	132	15.827	13	1.5587	7	0.8393
	1,325	295	22.26	1,030	77.74	910	68.68	191	14.415	9	0.6792	17	1.2830
	1,359	213	15.67	1,146	84.33	960	70.64	245	18.028	7	0.5151	26	1.9132
Total	4,065	867	.....	3,198	.....	2,680	.....	670	.....	33	.....	56	.....
Mean	.....	.....	**21.82**	.....	**78.18**	.....	**64.22**	.....	**16.729**	.....	**0.8711**	.....	**1.2831**
Probable error	.....	.....	±2.26	.....	±2.26	.....	±2.13	.....	±.657	.....	±.016	.....	±.015
Average	.....	.....	21.33	.....	78.67	.....	65.93	.....	16.482	.....	0.8118	.....	1.3776

TABLE 8. CLASSIFICATION OF PICKED BEN DAVIS APPLES FROM THE CATCHPOLE ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab				Leaf roller and green fruit-worm		Bud moth		Codling moth	
						Early		Late							
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	3,118	270	8.66	2,848	91.34	2,191	70.27	2,461	78.93	65	2.085	47	1.5074	*19	0.6094
	2,793	150	5.37	2,643	94.63	2,100	75.19	2,466	88.29	38	1.361	25	0.8951	0	.....
	2,837	540	19.03	2,297	80.97	1,453	51.22	1,978	69.72	68	2.397	11	0.3877	0	.....
	2,889	156	5.40	2,733	94.60	2,111	73.07	2,562	88.68	63	2.181	14	0.4846	0	.....
Total	11,637	1,116	.....	10,521	.....	7,855	.....	9,467	.....	234	.....	97	.....	19	.....
Mean	.....	.....	**9.62**	.....	**90.38**	.....	**67.44**	.....	**81.41**	.....	**2.006**	.....	**0.8187**	.....	**0.1523**
Probable error	.....	.....	±2.16	.....	±2.16	.....	±3.68	.....	±3.02	.....	±.15	.....	±.17	.....	±.10
Average	.....	.....	9.59	.....	90.41	.....	67.50	.....	81.35	.....	2.011	.....	0.8335	.....	0.1633
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons	2,789	1,938	69.49	851	30.51	554	19.86	579	20.76	52	1.864	8	0.2868	0	.....
	2,229	1,401	62.85	828	37.15	542	24.32	506	22.70	99	4.441	6	0.2691	0	.....
	2,760	1,771	64.17	989	35.83	204	7.39	287	10.40	79	2.862	5	0.1812	0	.....
	3,147	1,839	58.44	1,308	41.56	802	25.48	840	26.69	181	5.752	16	0.5084	1	0.0318
Total	10,925	6,949	.....	3,976	.....	2,102	.....	2,212	.....	411	.....	35	.....	1	.....
Mean	.....	.....	**63.74**	.....	**36.26**	.....	**19.26**	.....	**20.14**	.....	**3.730**	.....	**0.3114**	.....	**0.0079**
Probable error	.....	.....	±1.52	.....	±1.52	.....	±2.77	.....	±2.32	.....	±.58	.....	±.11	.....	±.027
Average	.....	.....	63.61	.....	36.39	.....	19.24	.....	20.25	.....	3.762	.....	0.3204	.....	0.0092
Sulfur 80, lead arsenate 20	2,812	761	27.06	2,051	72.94	1,429	50.82	1,383	49.18	49	1.743	43	1.5292	14	0.4979
	2,022	757	37.44	1,265	62.56	828	40.95	831	41.10	80	3.956	12	0.5935	1	0.0494
	2,673	846	31.65	1,827	68.35	1,018	38.08	1,269	47.47	141	5.275	8	0.2993	0	.....
	3,042	769	25.28	2,273	74.72	1,321	43.43	1,697	55.79	130	4.274	14	0.4602	0	.....
Total	10,549	3,133	.....	7,416	.....	4,596	.....	5,180	.....	400	.....	77	.....	15	.....
Mean	.....	.....	**30.36**	.....	**69.64**	.....	**43.32**	.....	**48.38**	.....	**3.812**	.....	**0.7206**	.....	**0.1368**
Probable error	.....	.....	±1.82	.....	±1.82	.....	±1.83	.....	±2.02	.....	±.500	.....	±.186	.....	±.081
Average	.....	.....	29.70	.....	70.30	.....	43.57	.....	49.10	.....	3.792	.....	0.7299	.....	0.1422
Sulfur 40, lead arsenate 10, gypsum 50	1,969	230	11.68	1,739	88.32	1,228	62.37	1,358	68.97	226	11.478	9	0.4571	1	0.0508
	2,082	290	13.93	1,792	86.07	1,444	69.36	1,206	57.93	239	11.479	29	1.3929	0	.....
	†1,470	153	10.41	1,317	89.59	996	67.76	1,226	83.40	104	7.075	3	0.2041	0	.....
	3,179	357	11.23	2,822	88.77	2,139	67.29	2,594	81.60	337	10.601	9	0.2831	17	0.5347
Total	8,700	1,030	.....	7,670	.....	5,807	.....	6,384	.....	906	.....	50	.....	18	.....
Mean	.....	.....	**11.81**	.....	**88.19**	.....	**66.69**	.....	**72.97**	.....	**10.158**	.....	**0.5843**	.....	**0.1464**
Probable error	.....	.....	±.50	.....	±.50	.....	±1.01	.....	±3.91	.....	±.704	.....	±.175	.....	±.086
Average	.....	.....	11.84	.....	88.16	.....	66.75	.....	73.38	.....	10.414	.....	0.5734	.....	0.2068
Sulfur 40, lead arsenate 10, hydrated lime 50	3,530	1,330	37.68	2,200	62.32	1,669	47.28	1,686	47.76	85	2.408	20	0.5666	0	.....
	2,832	1,248	44.07	1,584	55.93	965	34.07	1,231	43.47	47	1.660	25	0.8828	0	.....
	3,109	1,058	34.03	2,051	65.97	1,590	51.14	1,670	53.72	61	1.962	12	0.3860	0	.....
	3,170	1,482	46.75	1,688	53.25	1,290	40.69	1,346	42.46	57	1.798	28	0.8833	0	.....
Total	12,641	5,118	.....	7,523	.....	5,514	.....	5,933	.....	250	.....	85	.....	.....	.....
Mean	.....	.....	**40.63**	.....	**59.37**	.....	**43.29**	.....	**46.85**	.....	**1.957**	.....	**0.6797**	.....	.....
Probable error	.....	.....	±1.96	.....	±1.96	.....	±2.52	.....	±1.72	.....	±.108	.....	±.062	.....	.....
Average	.....	.....	40.49	.....	59.51	.....	43.62	.....	46.93	.....	1.978	.....	0.6724	.....	.....

*Calyx entrance. †Nine bushels. Ten bushels more from this tree were not recorded.

many others were infected. The control of both early and late scab is decidedly better on the sprayed plat than on any of the dusted ones, but even so the percentage of control is not very satisfactory. Judging from the fact that certain other parts of the Ben Davis orchard were said by the pickers to have been freer from scab than the experimental plats, it would appear, since those trees were sprayed some days earlier than the ones in the experiment, that the drenching rain came before the material had set properly. Unfortunately unpicked trees from such parts of the orchard could not be found for making a count to verify the impression of the pickers.

The dust mixtures were more completely removed from the trees by this torrent of rain, which occurred on the afternoon of the day when the applications were made, than was the solution; and thus the trees were only partially protected from the infections following on June 21 and continuing for four days.

Insect control.— The codling moth was too scarce in this orchard to make the experiments of any value in regard to its control. The bud moth was not abundant in the spring, and the count of the apples showed that the next generation, in late summer, was not numerous. Apparently enough of the poison was effective to slightly reduce the number of apples injured by bud-moth caterpillars in August.

EXPERIMENTS IN THE FRIEDAH ORCHARD AT OWEGO

The experimental orchard at Owego consisted of a block of two hundred and eighty-six Ben Davis trees, twenty-one years of age (Fig. 28). The trees are in the same orchard as was used by Blodgett in 1913 under the name of Lawson orchard. The orchard has not been cultivated or pruned in a number of years, and there was no cultivation this year. None of the trees have ever been sprayed except those treated by Blodgett in 1913. As there was no fruit in the Ben Davis block last year, and consequently no record in Blodgett's bulletin, the fact that some of the trees were treated last year was overlooked in planning the experiment. Since the foliage of the entire block was well infected with scab in 1913, owing to the omission of the first and fourth applications, the conditions were fairly uniform except for a part of plat 3, plat 4 (used as a check), and plat 5, which did not receive treatment last year. In these plats the amount of foliage was greatly reduced in 1913 by various caterpillars, so that the actual amount of infection material under these trees was less than under the others. Plats 3 and 4 were so arranged as to avoid the necessity of drawing a load up and down the hill, and also to prevent waste by leakage. Under the circumstances it would have been better if each plat had extended full length up and down the hill.

Methods and materials used

The dusting machine was like that used in the other orchards. The spraying outfit was the same as was used last year (Fig. 30). The spraying was all done from the ground, with 10-foot spray poles (Fig. 29). As Blodgett had considerable difficulty with the engine in 1913, the New Way Motor Company kindly furnished an upright (instead of horizontal) 1½-horsepower engine, with which it was thought that some of the former difficulty might be overcome. There was much less trouble from the engine stalling than last year, but the desired number of revolutions per minute of the blower could not be maintained, particularly on rough ground. As the trees were low and small, the effectiveness of the work was not materially impaired; but in high trees or trees with a large spread, the outfit would have been inadequate. Aside from this defect the dust applications in this orchard were applied most satisfactorily. If the morning was calm, the dust was applied at once; but if there was wind, the dusting was left until late in the day when the wind had gone down. The latter condition prevailed in the case of two applications.

The use of wheat flour as a diluent in the dust mixture was tried in this orchard. The presence of the flour made the mixture flow much more freely, and there was consequent difficulty in gauging the outlet in order

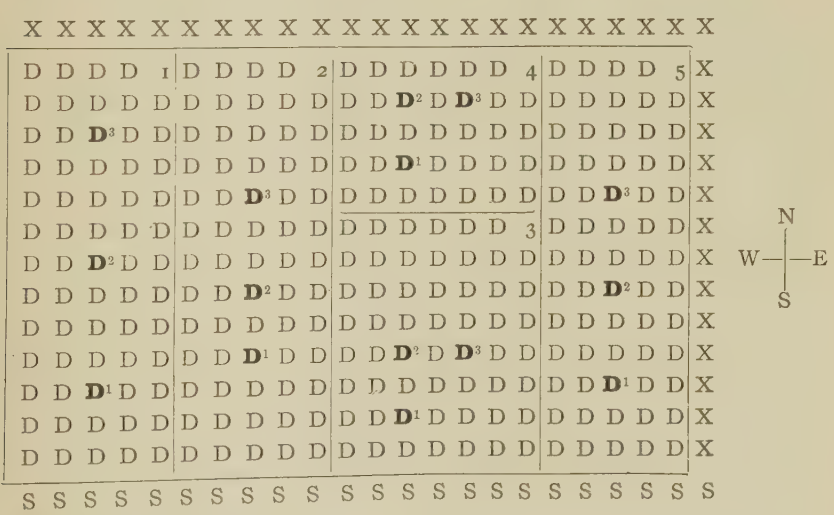


FIG. 28.— *Chart showing plan of experiment performed in the Friedah orchard, Owego, New York. The Ben Davis trees (D) enclosed in the black lines represent the various plats, and the trees indicated by bold-faced type are the trees from which the apples were counted. The exponents refer to the order in which the data are presented in the table. D, Ben Davis; S, Northern Spy; X, mixed varieties. In plat 3, count trees 1 and 2, and those adjacent, were treated in 1913 with sulfur paste; count tree 3 is in the untreated plat of 1913. None of the trees in plats 4 and 5 were treated in 1913*

to apply the desired quantity of material per tree. In the cost figures of Table 9 the price of wheat flour is taken as 3 cents per pound.

FIG. 29.—*Photograph made in the Friedah orchard. The size and shape of the trees is shown, also the method of applying the spray*

One plat (1) in this orchard was sprayed with a suspension of the finely ground sulfur of the dust mixture, to which was added 2 pounds of powdered arsenate of lead to each 100 gallons of water. The sulfur was easily brought into suspension by first wetting it with a weak glue solution.[7] A fine creamy paste resulted, which held up well and which passed very readily through the pump and the nozzles. Complete data on time and method of application are shown in Table 9. The cost of glue is not included in the cost of materials for the plat (1) treated with sulfur paste, and the time involved in driving to and from the orchard and in filling the tank is not included in the labor charges of the sprayed plats. This was never ess than thirty minutes for each 100 gallons of mixture.

No dormant treatment was made in this orchard, as San José scale was not known to exist there.

Three applications were made in the course of the summer, when the trees were in the same condition as in the other orchards. At the time of the first application, the spraying was done a day later than the dusting, but there was no intervention of rain or other unfavorable conditions. At the time of the second application, only the lower half of plat 3 was treated with lime-sulfur solution.[8] On the remainder of the plat sulfur paste was substituted. The treatment was the same for the third application.

[7] This mixture seems to have considerable value for certain spraying purposes. The exact method of preparation as used in this experiment is as follows: 2½ ounces of pulverized glue was dissolved in 2½ to 3 gallons of warm water; 20 pounds of the finely ground sulfur and 2 pounds of powdered arsenate of lead were weighed out into a large pail or other convenient receptacle. Glue solution was added as required, and was worked into the mixture by kneading with the hands. This required about five minutes. After the mixture was thoroughly wetted, it was thinned about one half with water and poured onto the strainer of the spray tank. The strainer consisted of a wooden box with a bottom of copper gauze, 20 meshes to the inch, supported by heavier galvanized gauze, 4 meshes to the inch. By turning the flow of water from the filling apparatus into the mixture, it was easily worked through the gauze with the hands or a brush.

[8] The shipment of lime-sulfur solution was lost in transit and none could be obtained in the vicinity; nor was quicklime available for boiling a small quantity.

As cankerworms and tent caterpillars threatened the destruction of the check plat, 2 pounds of powdered arsenate of lead was diluted with 50 pounds of wheat flour and dusted onto the trees of this plat on May 19. Although the quantity of poison applied was small, still it controlled these caterpillars fairly well, and on June 2 the foliage on these trees was in good condition and contrasted strikingly with the remaining untreated part of the orchard.

The relative quantities of essential ingredients applied per tree each time are on an average as follows: plat sprayed with lime-sulfur, sulfur 3.14 ounces, lead arsenate .99 ounce; plat dusted with 80-per-cent sulfur mixture, sulfur 21.89 ounces, lead arsenate 5.47 ounces; plat dusted with mixture containing wheat flour as a diluent, sulfur 13.44 ounces, lead arsenate 3.36 ounces; plat sprayed with paste sulfur, sulfur 8.32 ounces, lead arsenate .83 ounce.

Scab infection periods

In this orchard, as in the others, the scab disease was the only one of consequence. The early-infection period of May 11, 12, and 13 occurred in about the same severity as in the other orchards. At Waverly, in the Susquehanna Valley twenty miles west of Owego, there were periods that would permit a certain amount of infection on May 23, 26, and 27, May 29 and 30, June 4 and 5, June 7 and 8, June 15 and 16, June 19 to 22 inclusive, and June 27 to 29 inclusive. The infection periods during July were more numerous here than in the other orchards, but, as elsewhere, the majority of late-infection periods occurred in mid-August.

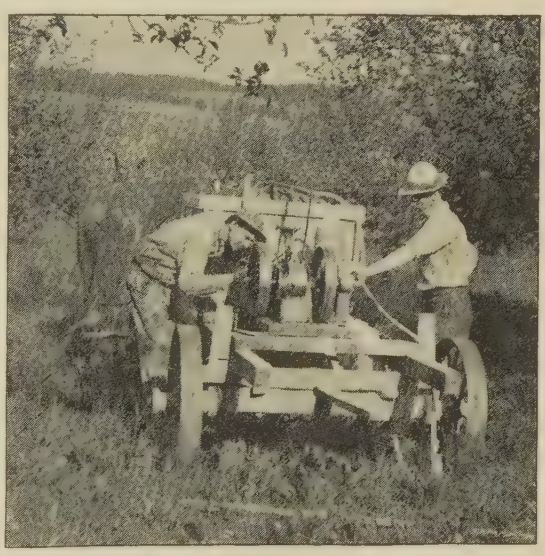


FIG. 30.—*Spraying outfit used in the Friedah orchard. Difficulty with the engine delayed the work and made many of the time records worthless*

Insects of the season

This orchard was badly infested by cankerworms, apple tent-caterpillars, and forest tent-caterpillars, and in the untreated part of the orchard many of the trees were nearly defoliated by these insects. Bud moths were no more abundant

TABLE 9. DATA ON TIME AND METHODS OF APPLICATION, FRIEDAH ORCHARD, OWEGO, NEW YORK

Date of application	Plat	Number of trees	Materials used, and strength	Quantity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Material	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
				(Gals.)										
May 20	3	56	Lime-sulfur solution (32°)	150	*2	06	*3	09	*1	03	$ .84	$1.44	$2.28	$.041
June 2	3	56	2.5 gallons, lead arsenate	200	2	06	3	09	1	03	.84	1.92	2.76	.049
June 20	3	56	2 pounds, water to make	170	2	06	3	09	1	03	.84	1.63	2.47	.044
			100 gallons											
Totals	....	....	.....	520	6	18	9	27	3	09	$2.52	$4.99	$7.51	$.134
				(Lbs.)										
May 19	2	65		65	0	40	0	40	0	20	$.20	$ 3.43	$ 3.63	$.056
June 2	2	65	Sulfur 80, lead arsenate 20	140	1	10	1	10	0	35	.35	7.39	7.74	.119
June 20	2	65		130	1	20	1	20	0	40	.40	6.86	7.26	.112
Totals	....	....	.....	335	3	10	3	10	1	35	$.95	$17.68	$18.63	$.287
May 19	5	65		90	0	36	0	36	0	18	$.18	$ 3.73	$ 3.91	$.060
June 2	5	65	Sulfur 40, lead arsenate 10,	170	1	16	1	16	0	38	.38	7.04	7.42	.114
June 20	5	65	wheat flour 50	150	1	12	1	12	0	36	.36	6.21	6.57	.101
Totals	....	....	.....	410	3	04	3	04	1	32	$.92	$16.98	$17.90	$.275
				(Gals.)										
May 20	1	65	Sulfur 20 pounds, lead arsen-	160	2	06	3	09	1	03	$ .84	$1.25	$2.09	$.032
June 2	1	65	ate 2 pounds, water to	200	2	06	3	09	1	03	.84	1.56	2.40	.037
June 20	1	65	make 100 gallons	150	2	06	3	09	1	03	.84	1.17	2.01	.031
Totals	....	....	.....	510	6	18	9	27	3	09	$2.52	$3.98	$6.50	$.100

* The figures given here are the average of time required per tree multiplied by the number of trees of all the satisfactory runs made throughout the season. A number of runs were greatly disrupted by various sorts of troubles. The average given here is much more nearly correct than would be the actual time involved.

than in the Catchpole orchard, but cigar case-bearers were very plentiful. Leaf rollers were abundant, but some of the injury attributed to these insects at the time of counting may have been caused by tent caterpillars and possibly by the white-marked tussock-moth caterpillar. For some unknown reason, the codling moth was not so abundant as would be expected in an orchard so badly neglected.

Results of experiments

Scab control.— The first applications, on May 19 and 20, were made opportunely to afford protection against infections occurring late in May. As the primary infections of May 11 had not developed conidia until near June 1, infections occurring in May were from ascospores. The number of infections was obviously much less than if conidia had been present, and the amount of pedicel infection was so slight as to be a negligible factor. Judging from the other orchards, it is probable that conidia were liberated from scab spots on May 29 and 30, when the conditions apparently were very favorable for infection. The blossoms had all fallen on this date, and the Waverly record shows dense fog on May 29 with slight precipitation on May 30. Subsequent observations indicate strongly that a large amount of secondary infection occurred at this time. The second application, on June 2, afforded protection against the infections of June 4 and 5, which was decidedly the most favorable period for infection prior to the rains beginning on June 19.

The third application, on June 20, following the heavy rain during the afternoon and night of June 19, unquestionably was made too late to prevent the greatest infection of the season, although additional infections occurring on June 21 and 22 were forestalled.

By July 1, when the orchard was examined, it was evident that there was a large amount of scab infection on all the treated plats. Drops in this orchard were destroyed by hogs, except those that were caught in cheesecloth hammocks. The pedicels were practically free from infection, and, as there was no indication on July 1 that the scab disease was in any way responsible for the dropping of fruit, no record was made of the percentage of scab on the small number of drops caught. No thinning was done in this orchard. The late application was omitted intentionally.

It is obvious from Table 10 that very poor control of scab resulted on any of the plats. The order of effectiveness of early-scab control for the various materials may be an indication of the relative value of the substances tested, but this order coincides with the order of application of the materials at the time of the third application. Plat 3 (lime-sulfur solution) was treated in the morning, plat 1 (sulfur paste)

TABLE 10. CLASSIFICATION OF PICKED BEN DAVIS APPLES FROM THE FRIEDAH ORCHARD, OWEGO, NEW YORK

Treatment	Total number of apples	Sound		Unsound		Apple scab				Leaf roller and green fruit-worm		Bud moth		Codling moth	
						Early		Late							
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	629	1	0.16	628	99.84	620	98.57	608	96.66	145	23.05	3	0.4769	14	2.2258
	556	1	0.18	555	99.82	550	98.92	530	95.32	148	26.62	2	0.3597	16	2.8777
	1,000	0	0	1,000	100.00	952	95.20	973	97.30	297	29.70	3	0.3000	16	1.6000
Total	2,185	2	.....	2,183	.....	2,122	.....	2,111	.....	590	.....	8	.....	46	.....
Mean	.....	.....	**0.11**	.....	**99.89**	.....	**97.56**	.....	**96.43**	.....	**26.46**	.....	**0.3789**	.....	**2.2345**
Probable error	.....	.....	±.038	.....	±.038	.....	±.76	.....	±.04	.....	±1.36	.....	±.035	.....	±.247
Average	.....	.....	.09	.....	99.91	.....	97.12	.....	96.61	.....	27.00	.....	0.3661	.....	2.1053
Lime-sulfur solution (32°) 2.5 gallons, lead arsenate 2 pounds, water to make 100 gallons	4,126	2,236	54.19	1,890	45.81	1,262	30.59	1,384	33.54	268	6.50	12	0.2908	2	0.0485
	2,418	1,393	57.61	1,025	42.39	565	23.37	619	25.60	350	14.47	5	0.2068	0	.....
	2,049	873	42.61	1,176	57.39	837	40.85	891	43.48	237	11.57	3	0.1464	2	0.0976
Total	8,593	4,502	.....	4,091	.....	2,664	.....	2,894	.....	855	.....	20	.....	4	.....
Mean	.....	.....	**51.47**	.....	**48.53**	.....	**31.60**	.....	**34.21**	.....	**10.85**	.....	**0.2147**	.....	**0.0487**
Probable error	.....	.....	±3.04	.....	±3.04	.....	±2.42	.....	±3.46	.....	±1.56	.....	±.345	.....	±.0189
Average	.....	.....	52.39	.....	47.61	.....	31.00	.....	33.68	.....	9.95	.....	0.2321	.....	0.0466
Sulfur 80, lead arsenate 20	3,485	1,013	29.07	2,472	70.93	1,508	43.27	2,293	65.80	112	3.21	12	0.3443	2	0.0574
	2,666	846	31.73	1,820	68.27	1,074	40.29	1,622	60.84	66	2.48	7	0.2626	0	.....
	2,641	501	18.97	2,140	81.03	1,748	66.19	1,994	75.50	249	9.43	6	0.2272	7	0.2651
Total	8,792	2,360	.....	6,432	.....	4,330	.....	5,909	.....	427	.....	25	.....	9	.....
Mean	.....	.....	**26.59**	.....	**73.41**	.....	**49.92**	.....	**67.38**	.....	**5.04**	.....	**0.2780**	.....	**0.1075**
Probable error	.....	.....	±2.61	.....	±2.61	.....	±5.48	.....	±2.89	.....	±1.47	.....	±.048	.....	±.054
Average	.....	.....	26.84	.....	73.16	.....	49.25	.....	67.21	.....	4.86	.....	0.2843	.....	0.1024
Sulfur 20, lead arsenate 2, water to make 100 gallons	4,014	1,753	43.67	2,261	56.33	1,337	33.31	2,060	51.32	67	1.67	18	0.4484	9	0.2242
	2,978	978	32.84	2,000	67.16	1,130	37.94	1,368	45.94	100	3.36	0	.....	0	.....
	3,034	886	29.20	2,148	70.80	1,410	46.47	1,669	55.01	546	18.00	5	0.1648	6	0.1978
Total	10,026	3,617	.....	6,409	.....	3,877	.....	5,097	.....	713	.....	23	.....	15	.....
Mean	.....	.....	**35.24**	.....	**64.76**	.....	**39.24**	.....	**50.76**	.....	**7.68**	.....	**0.2044**	.....	**0.1407**
Probable error	.....	.....	±2.91	.....	±2.91	.....	±2.59	.....	±1.76	.....	±3.47	.....	±.088	.....	±.047
Average	.....	.....	36.08	.....	63.92	.....	38.67	.....	50.84	.....	7.11	.....	0.2294	.....	0.1496
Sulfur 40, lead arsenate 10, wheat flour 50	*1,000	231	23.10	769	76.90	564	56.40	693	69.30	96	9.60	.....	.....	0	.....
	*1,000	337	33.70	663	66.30	460	46.00	443	44.30	200	20.00	.....	.....	0	.....
	*1,000	275	27.50	725	72.50	573	57.30	563	56.30	109	10.90	.....	.....	0	.....
Total	3,000	843	.....	2,157	.....	1,597	.....	1,699	.....	405	.....	.....	.....	.....	.....
Mean	.....	.....	**28.10**	.....	**71.90**	.....	**53.23**	.....	**56.63**	.....	**13.50**	.....	.....	.....	.....
Average	.....	.....	28.10	.....	71.90	.....	53.23	.....	56.63	.....	13.50	.....	.....	.....	.....

*Not all the apples from the trees were counted.

was begun at one o'clock in the afternoon and finished about four o'clock, and the two dusted plats were treated after five o'clock in the afternoon. In view of the observations and records of Wallace[9] (page 570 and Plate XI of reference cited), it seems quite possible that the application of lime-sulfur made approximately eighteen hours after the rains set in prevented a certain amount of infection which applications six hours later, or even one hour later, would not have prevented. One of the strongest reasons for believing that this factor enters is that in Blodgett's experiments[10] sulfur dust and sulfur paste were equally effective in scab control, whereas in this orchard the difference is pronounced (being 10 per cent), and the difference between the percentage of scab control with lime-sulfur solution and either dust or paste is much greater than it was last year.

The control of late scab, as in the Glidden orchard, varies directly with the control of early scab, and, as in the other orchards, apples bearing early-scab spots were almost certain to show late infection also.

Insect control.— In this orchard all the treatments greatly decreased the injury caused by leaf roller, the best results being obtained by the use of the sulfur and lead arsenate in dust form. Only 2.1 per cent of the apples in the check plat were injured by the codling moth; all the treatments given reduced this injury to less than 1 per cent.

GENERAL SUMMARY

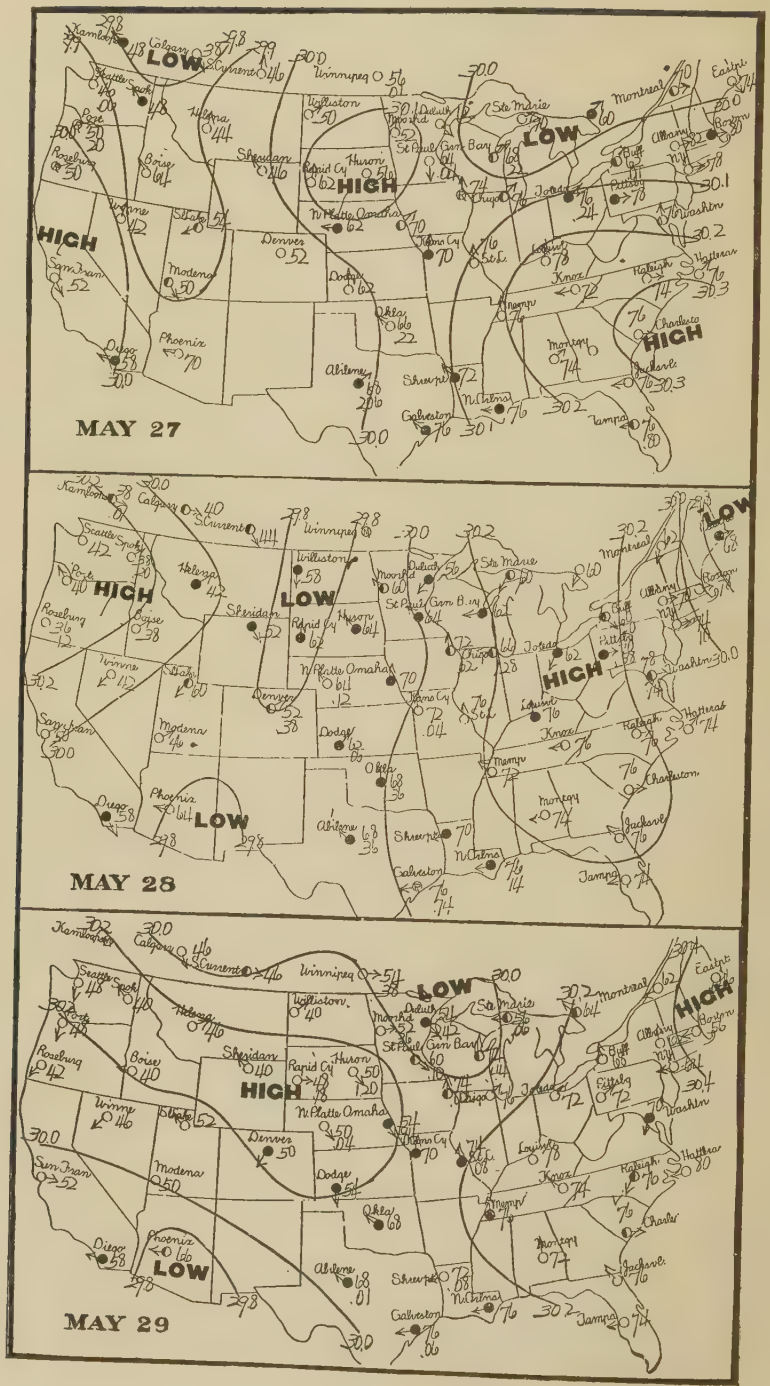
Material progress has been made in answering the six points to be determined as outlined at the beginning of this bulletin, and a number of additional observations bearing on the general project may be recorded:

1. The dust method seems to be particularly applicable to large old trees, with which the difficulty in doing thorough spraying is most apparent.

2. It is well understood that, in dealing with nature, things rarely happen twice alike. With the information now at hand, a schedule could be made which, if followed, would give a complete and satisfying answer to the second point. Whether or not the results of last year have been duplicated or improved may appear to depend on which orchard is chosen or on an average of the three orchards. It does not. It depends on an interpretation of the data secured in the light of known biological and physical phenomena, and in this instance more particularly in the light of the facts known about the apple scab fungus.

That the scab fungus would mature earlier than usual in 1914 might have been determined in advance, but the practicability of making an application of spray to prevent the early infection is doubtful. It probably would have been a physical impossibility in two of the orchards,

[9] Wallace, Errett. Scab disease of apples. Cornell Univ. Agr. Exp. Sta. Bul. 335 : 545–624. 1913.
[10] See Table 5 in Bulletin 340 of the Cornell University Agricultural Experiment Station.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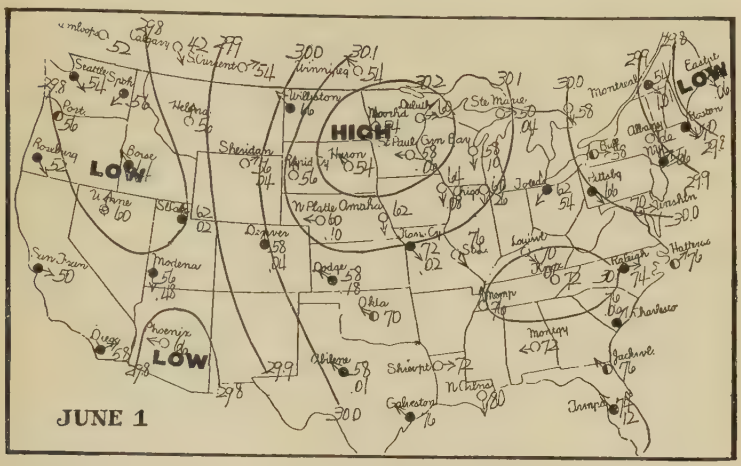
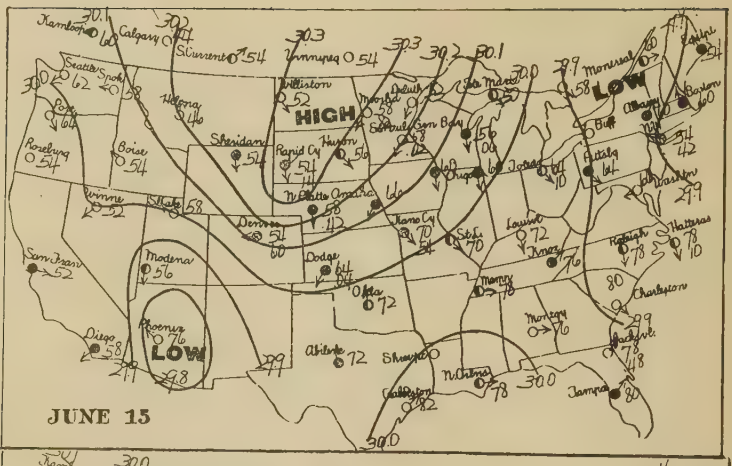


FIG. 31.—*Reproduction of the weather maps issued on May 27, 28, 29, and June 1. Conditions on May 27 were favorable for rain within a few hours. The "Low" central over Lake Huron on this date had been moving eastward for two days, and caused the writers great anxiety. The fact that the center was above the lakes afforded some relief, but the map of May 28 revealed a new menace. This area fortunately lost in intensity, but permitted some rainfall on May 30 (May 30 being a holiday, no map was made on that day)*

because of the soft condition of the soil. A dusting outfit could have been used. Such an application would have afforded no pedicel protection, but this year such protection was not needed.

The second application should have been made earlier. The trees were in a suitable stage for treatment several days earlier than the actual date of application. While this fact was fully realized at the time, and weather charts (Fig. 31) indicated the occurrence of rain, one of the writers (C) was at that time unfamiliar with the details of the experiments and the other was detained in Ithaca with five days of work which could not be delegated. That the infection at Holley was slight on May 28 is purely accidental, since general conditions existed which might have permitted a considerable infection.

The third application was being timed with special reference to codling moth, but of course due regard was taken of possible scab-infection periods. It was decided tentatively by one of the writers (C) to begin the work of making the application on June 18. Weather conditions on the previous days, as can be seen from the accompanying reproductions of the maps for those days (Fig. 32), did not indicate that a serious disturbance was imminent, and indeed the forecast of the observers on June 18 was for fair weather. It will be noticed from the maps that an area of insignificant extent was responsible for the downpour of June 19. Again,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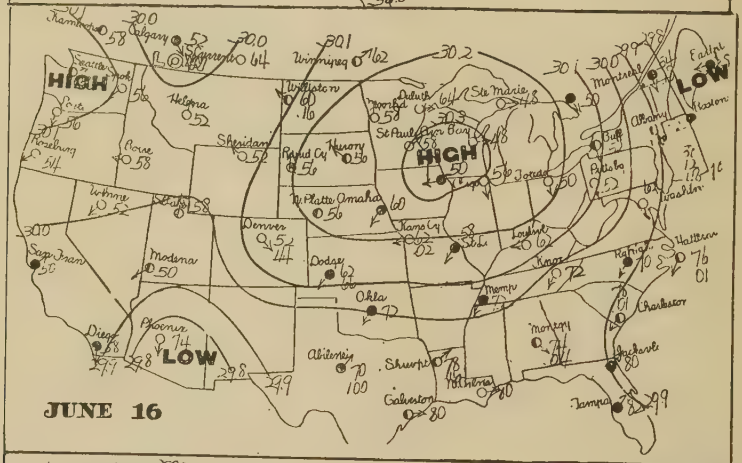
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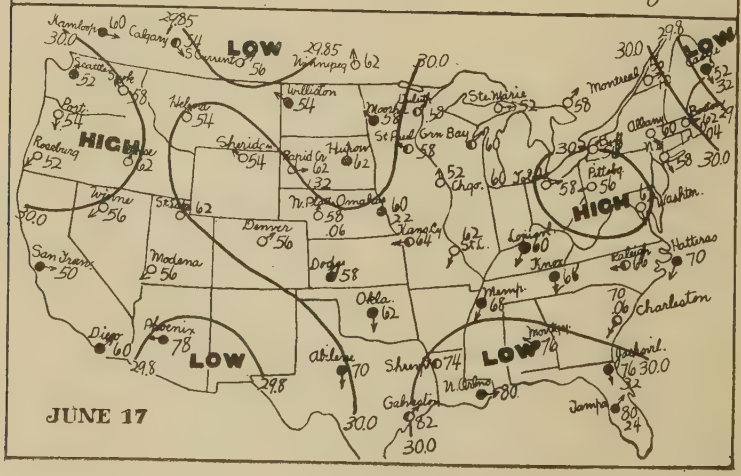
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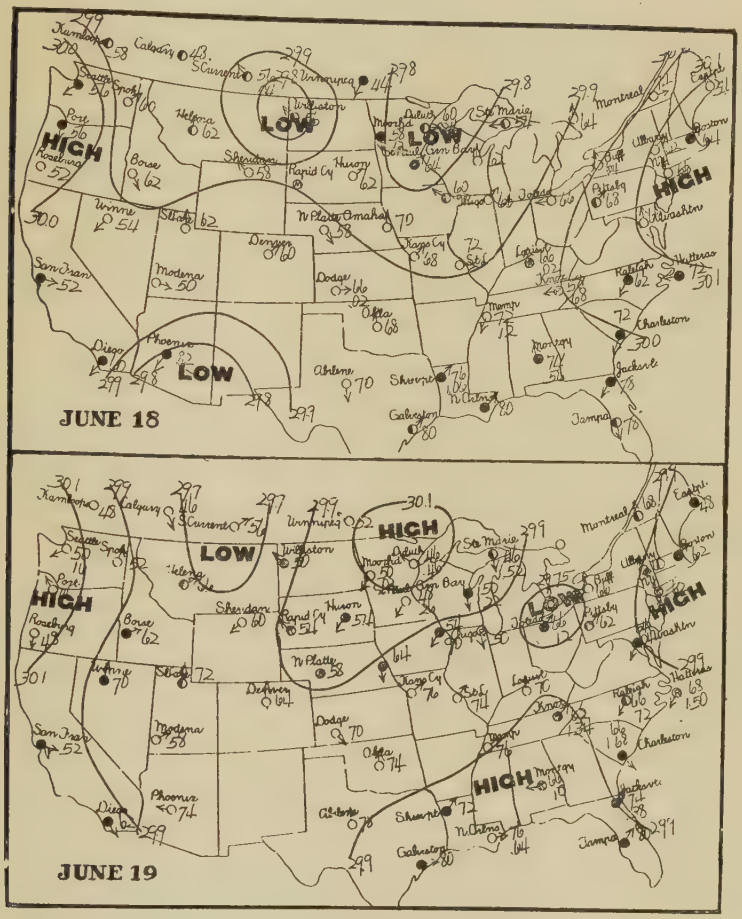

FIG. 32.—*Reproduction of the weather maps issued on June 15, 16, 17, 18, and 19, 1914. The disturbance (indicated by the word "Low") in the Canadian Northwest on June 17 might have been expected to reach New York in three or four days, thus allowing ample time to protect all the experimental orchards. Instead, on June 18 there are two storm centers, and at eight o'clock in the morning on June 19 one of them is central over Lake Erie. The area was insignificant in extent, but it was large enough to involve all three orchards*

it was, in a way, only accidental that the Glidden orchard was treated in time to forestall the heavy infection of June 19. The low barometer showing for the first time on June 17 in the Canadian Northwest was the one that might bring rain. That it would split, and a small part move across the country at great velocity, bringing in its wake a torrent of rain that would involve the three rather widely separated experimental orchards, was certainly not anticipated by the writers, who do not profess

to be weather prophets. As a result of the disturbance, the general unsettled condition indicated in the map of June 20 reached western New York on June 21 and continued for four days.

The test in the Glidden orchard was a fairly severe one, inasmuch as the unsprayed trees, which previously had been well sprayed annually for at least seven years, developed 35 per cent of scabby apples.

In the writers' opinion, therefore, the results obtained in the Glidden orchard should receive the most consideration, and on that basis the question may be answered by saying that the results of 1913 have been approximated so far as scab is concerned.

Aside from insect and disease control, the mechanical difficulties of former years were decidedly reduced, and from this standpoint the work of the season has been a great improvement over that of former years.

The removal of mechanical difficulties has made it possible to secure more reliable cost data than could be obtained formerly, and it now appears that an orchard may be protected by dusting at the same cost per tree as by spraying, or at less cost.

3. The tests of the various mixtures on insect control were not so severe as in former years, and the absence of codling moth in all three orchards leaves the control of this important pest out of consideration. It appears, however, that the dust mixtures containing 10 per cent of arsenate of lead are as effective as those containing twice the quantity.

4. It would appear that the quantity of sulfur applied per tree may be reduced. By comparing the percentage of early apple scab in plats 3 and 5 of the Glidden orchard, or in the two dusted plats in the Friedah orchard, it will be seen that they are very close together. This can only indicate that some trees received 50 per cent more sulfur than was necessary. The fact that the gypsum plat in the Catchpole orchard runs higher in scab is thought to be an indication of less thorough application (because of wind) rather than of reduced fungicidal value.

5. To the fifth question a satisfactory answer has not been secured. The results with hydrated lime are indecisive, as they are quite different in the two orchards where this substance was used. In the Glidden orchard the heavy shower following immediately after the first application of the mixture containing lime may have washed off the material before it was set, while in the Catchpole orchard the more favorable showing of the lime-dusted plat may be attributed to one of two things — the application of bordeaux mixture on May 14, or more satisfactory applications of dust due to the fact that adjacent woods broke the force of the wind in this area. The latter is the more probable explanation.

The use of gypsum did not seem to add to or detract from the adhesiveness of the mixture.

Wheat flour did not add materially to the adhesive properties of the mixture, and the expense of this substance practically precludes its use.

6. The paste sulfur, although applied very cheaply, does not seem to be the equal of lime-sulfur solution. However, the test cannot be regarded as conclusive.

OTHER GENERALIZATIONS

In addition to the above considerations, observations have been made on a number of points about which there has been considerable inquiry.

Destruction of fallen leaves

That fallen leaves are the source of primary scab infection in these orchards is unquestionable. It is also very evident from this work that the amount of secondary infection is directly dependent on the abundance of primary infection. Everything points to the conclusion that the early destruction of the fallen leaves (sometime previous to May 11) would have materially reduced the number of primary infections and would have made the control of secondary infections easier. At least two of the orchards might have been plowed at any time during the month of December, 1913. It is doubtful whether any of them could have been plowed in April or early May of 1914, because of the wet condition of the soil. Plowing under the old leaves, however, will never be so effective as to make the application of fungicides unnecessary.

What makes dust stick?

There have been many inquiries as to what it is that makes the dust preparations adhere to the foliage. There seem to be at least two factors involved, possibly more. During the early period of growth of the leaf and the fruit, a dense mat of fine plant hairs covers each. The particles of the dust mixture are fine enough to lodge between these hairs, and are there protected from wind and rain. It appears, therefore, that the fineness of the material is an important item.[11] The same hairs are effective in holding many spores of the scab fungus in place until they have had time to germinate.

The other factor of importance is the adhesive nature of some of the lead compounds. The white lead of commerce is well known because of this property. When lead arsenate is moistened, it becomes somewhat gelatinous and is difficult to wash off completely. This was brought forcibly to the attention of one of the writers (R) when, after completing a job of dusting, he undertook to wash the dust from his hair with soap and water.

[11] The sulfur used in all these experiments is much finer than the ordinary sulfur flour or even flowers of sulfur. At least 95 per cent will pass a 200-mesh screen. Comparative sizes of individual particles of the various kinds of sulfur are illustrated by photomicrographs, and the method of testing the fineness is described by Blodgett (Cornell Univ. Agr. Exp. Sta. Bul. 328 : 306-310, figs. 108–110. 1913).

Each hair seemed to become covered with a film of the mixture. Finally a barber was resorted to for relief. This homely experience has increased the writers' respect for the adhesiveness of a mixture containing arsenate of lead, and leads them to believe that this may help to explain how the mixture sticks to the trees. The moisture, of course, is supplied by the dew of the succeeding night or by gentle rains.

Must dust be applied at special times?

There is an idea prevalent that dust must be applied very early in the morning in order that advantage may be taken of the dew on the trees. Doubtless this would be an advantage in causing the mixture to set at once, but in the minds of most New York orchardists it is impracticable. In localities where wind is a factor, early morning applications before the wind comes up would be desirable. It usually happens, however, that there are a few days of calm weather between the storm periods, during which dusting or spraying can be done advantageously.

Aside from the points mentioned above, the time of application of dust does not differ from that of applying spray with possibly one exception. If before a given application is finished a heavy rain should come early in the morning (as early as three o'clock) and be followed by a day of fog, it would be profitable to run the duster at full capacity for most of the day. Spraying, of course, could not be done because of wet ground and the drip from the foliage.

Is there danger from breathing the dust?

In regular work there is little necessity for breathing the dust, except for the slight leakage about the machine, in turning at the ends of rows when there is some wind, and in filling the hopper. In case of frequent changes of materials and in the short rows of experimental work, a number of different persons (the writers included) have breathed considerable quantities of the dust. No inconvenience has been experienced by any one, and no unfavorable symptoms of anything like lead poisoning.

Special equipment needed

Aside from the mounted dusting machine and engine, no special equipment is needed except a pair of goggles for the operator and one for the driver. A very small quantity of sulfur dust in the eyes causes an irritation which becomes noticeable only after an hour or more and which is aggravated by rubbing. A pair of goggles that fit tightly about the eyes and cover the least possible extent of surface is desirable. The larger kinds are likely to become fogged from perspiration.

Sow oats, or dust?

Every fruit grower knows that there are times when the teams on the spraying outfit are sorely needed for plowing, for fitting the land, or for seeding. By employing the dust method, the labor item in protecting the orchard may be reduced nearly one fourth. Whether the duster or sprayer should be run on any certain day in preference to doing other farm work, is the one point about which effective disease control hinges. First of all, the trees must be in condition for an effective application. Aside from that, the determining point should be based on a prognostication of the next storm period. If the dependence of scab infection on rainfall and attendant weather conditions was ever in doubt, the work presented in this bulletin would dispel such doubt. Any one can learn to make intelligent use of the forecasts of the United States Weather Bureau, and by going back of the twenty-four-hour forecast and examining the maps from which the forecast was made one can determine in a general way what may happen in the next two or three days. If there are probabilities of a general storm period within forty-eight hours, the orchard should be protected regardless of other farm operations. If no maps can be consulted, but the wind is in the east and has been in the east or the northeast on the day before, there is sufficient reason in most parts of the State for running the duster in preference to the grain drill. The oats will grow if put in after the rain, but orchard treatments after the rain will not prevent scab infection.

Who shall dust?

There is no indication that the spray machine can be thrown on the scrap heap. In fact, with our present knowledge, it is quite certain that the trees must be sprayed in the dormant stage just as in the past. The man who can cover his entire orchard in three to four days will doubtless continue spraying as in the past. Where the relation of orchard to farm is such as to throw an unusual load of labor on men and teams during May and June, and where the orchard is of such extent that it is practically impossible to equip enough outfits to do the spraying at critical times, the duster will afford necessary relief. For the present, at least, it seems desirable, in case both duster and sprayer are used, to apply the liquid to varieties most susceptible to scab.

On a good day — and there are usually two or more comparatively calm days between storm periods at this time of year — one can expect to cover six hundred to nine hundred trees in ten hours. If the trees are small and the horses walk briskly, more trees can be covered. This experimental work has been done almost entirely from the point of view of the commercial orchardist. Its applications, however, extend to practically all owners of apple trees, and particularly to the general farmer with a few trees in the

home orchard. It is very exceptional to find small orchards that are sprayed. On the general farm the dates of application are too inopportune, and it usually happens that the only spraying outfit available is traction-driven. Such outfits usually do not give satisfaction in the orchard. With the dust method one man, the hack horse hitched to the democrat wagon, and a small hand machine that is always in readiness for operation, are the only equipment necessary.

What materials shall be used?

The tests of recent years have been made with a very fine sulfur flour combined with dry arsenate of lead, and any combination other than this should be used only in an experimental way. Whether an inert carrier, such as powdered gypsum, should be added, or whether a smaller quantity of the undiluted mixture should be applied per tree, is an open question. For the present it would be advisable to use a mixture of 90 parts of pure sulfur specially finely ground and 10 parts of powdered arsenate of lead, applying, on an average, $1\frac{1}{2}$ to 3 pounds of the mixture per tree at each application. If the grower desires to compound his materials he should procure a suitable mixing outfit. Experience in diluting lead arsenate for the treatment of the check plat in the Friedah orchard makes it certain that, with the average equipment about the farm, a grower cannot make a suitable mixture economically.